DATE ISSUED AUG 25 1978

ORNL-5420

780412

559

Industrial Safety and Applied Health Physics Annual Report for 1977

559

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION · FOR THE DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy $6.50; Microfiche $3.00

ORNL-5420
Dist. Category UC-41

Contract No. W-7405-eng-26

INDUSTRIAL SAFETY AND APPLIED HEALTH PHYSICS ANNUAL REPORT FOR 1977

J. A. Auxier, Director

D. M. Davis, Associate Director

JUNE 1978

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

TABLE OF CONTENTS

FOREWORD

This report describes and summarizes the activities of the Industrial Safety and Applied Health Physics Division. Information in this report was contributed by, and/or compiled by the following staff members of the Division:

<u>Radiation Monitoring</u>

E. D. Gupton

<u>Environmental Surveillance</u>

T. W. Oakes
K. E. Shank

<u>Radiation and Safety Surveys</u>

R. L. Clark

<u>Industrial Safety and Special Projects</u>

A. D. Warden

INDUSTRIAL SAFETY AND APPLIED HEALTH PHYSICS DIVISION

J. A. AUXIER, DIRECTOR
W. S. NICHOLS,[4] SECRETARY
D. M. DAVIS, ASSOCIATE DIRECTOR
B. A. WIEMAN, SECRETARY

ADMINISTRATIVE AIDE
J. L. MALONE

FINANCE OFFICER
T. J. BURNETT

ASSISTANT FINANCE OFFICER
D. W. GADDIS

ENVIRONMENTAL SURVEILLANCE AND EVALUATION
T. W. OAKES*

- **SECRETARIAL STAFF**
  L. J. BROWN
- **ATMOSPHERIC AND AQUATIC SURVEILLANCE**
  J. M. DAVIS*
  W. B. TOWNS*
- **BIOLOGICAL AND TERRESTRIAL SURVEILLANCE**
  J. M. DAVIS*
  H. M. HUBBARD*
  L. R. QUINTANA*
- **DATA EVALUATION AND SPECIAL PROJECTS**
  T. W. OAKES*
  K. E. SHANK[6]
  C. E. EASTERLY[7]
  H. M. HUBBARD*
  K. F. MIRZA[8]
  L. R. QUINTANA*
  W. B. TOWNS*

RADIATION MONITORING
E. D. GUPTON

- **SECRETARIAL STAFF**
  D. W. GADDIS
- **INSTRUMENTATION**
  E. D. GUPTON
  D. R. CLARK
  G. L. ARTHUR
  I. T. FANN
  J. E. JACKSON
  S. W. NICHOLS
- **DOSE DATA**
  J. R. MUIR
  R. W. LANE
  D. M. SOARD
  J. H. WILLIAMS
- **INTERNAL DOSE**
  W. W. PARKINSON
  R. E. GOANS
  W. M. GOOD
- **PERSONNEL METERS**
  D. R. CLARK
  B. B. HERREL
  M. L. LEE
  M. R. MATTHEWS
  R. C. KUHLO
- **RADIOASSAYS**
  L. C. HENLEY
  J. C. ANDERSON
  M. J. SMITH
  A. J. SOARD

INDUSTRIAL SAFETY AND SPECIAL PROJECTS
A. D. WARDEN*

- **SECRETARIAL STAFF**
  M. R. DUNSMORE
- **SAFETY**
  D. C. GARY[2]
  R. E. MILLSPAUGH*
  E. M. ROBINSON[5]
- **ORIENTATION AND TRAINING**
  R. E. MILLSPAUGH*
- **PROGRAM AND FACILITIES REVIEW**
  T. J. BURNETT*
- **BALANCE AREA REPRESENTATIVE**
  T. J. BURNETT*
- **STANDARDS AND PROCEDURES**
  A. D. WARDEN*

RADIATION AND SAFETY SURVEYS
R. L. CLARK

- **SECRETARIAL STAFF**
  B. A. CAMPBELL
- **BUILDING SURVEYS GROUP 1**
  B. T. WALTERS*
  - **CENTRAL**
    W. T. MARTIN
    B. C. BURRELL
    R. D. PARTEN
    J. R. SLATEN
    D. K. THOMAS
  - **SOUTH CENTRAL**
    B. T. WALTERS*
    A. C. BUTLER
    J. V. HILYER
    J. H. SPENCE
  - **EAST**
    H. M. BUTLER[1]
    J. F. ALEXANDER
    W. D. CARDEN
    T. L. COLLINS
    A. B. ELDRIDGE
    C. E. HAYNES
    C. F. JACKSON
    R. E. KENY
    W. F. OHNESORGE
  - **SOUTHEAST**
    A. J. SMITH
    W. A. ALEXANDER
    T. G. CLARK
    R. B. MALCOLM
- **BUILDING SURVEYS GROUP 2**
  L. C. JOHNSON
  - **NORTHWEST**
    C. H. MILLER
    M. L. CONNER
    W. M. JOHNSON
    W. A. McLOUD
    G. R. PATTERSON
    C. F. ZAMZOW
  - **NORTH CENTRAL**
    J. A. WORTH
    J. H. PEMBERTON
  - **MELTON VALLEY**
    R. E. COLEMAN
    W. F. FOX
    J. C. RICHTER
    R. L. WALKER
  - **Y-12 OPERATIONS**
    J. C. DAVIS
    A. CARDWELL
    P. E. COX
    R. E. HALLIBURTON
    R. S. HOWELL[3]
- **SHIFTS AND AREA SURVEYS**
  C. R. GUINN
  - **SHIFTS SUPERVISORS**
    J. S. ADDISON
    R. C. COOPER
    R. L. JEFFERS
    D. G. NOE
  - **AREA SURVEYS**
    C. CLARK
    C. F. SMITH
    I. H. WIGGINS

JUNE 30, 1977

*DUAL CAPACITY
[1]RADIATION CONTROL OFFICER
[2]DIVISION SAFETY OFFICER
[3]LEAVE OF ABSENCE
[4]AFFIRMATIVE ACTION REPRESENTATIVE
[5]QUALITY ASSURANCE COORDINATOR
[6]ENERGY CONSERVATION OFFICER
[7]HEALTH AND SAFETY RESEARCH DIVISION
[8]IAEA FELLOW.

2.0 SUMMARY

RADIATION MONITORING

Personnel Monitoring

There were no external or internal exposures to personnel which exceeded the standards for radiation protection as defined in DOE Manual Chapter 0524. Only 51 employees received whole body radiation exposures of 1 rem or greater. The highest whole body dose equivalent to an employee was 3.6 rem. The highest internal exposure was less than one-half of the maximum permissible body burden.

Health Physics Instrumentation

During 1977, 13 portable instruments were added to the inventory and 86 retired. The total number in service on January 1, 1978, was 1,210. There were six facility radiation monitoring instruments installed and eleven retired during 1977. The total number in service on January 1, 1978, was 1,044.

ENVIRONS SURVEILLANCE

Atmospheric Monitoring

There were no releases of gaseous waste from the Laboratory which were of a level that required an incident report to DOE. The average concentration of beta radioactivity in the atmosphere at the perimeter of the DOE-controlled area was less than one percent of the value applicable to releases to uncontrolled areas.

Water Monitoring

There were no releases of liquid waste from the Laboratory which were of a level that required an incident report to DOE. The quantity of radionuclides of primary concern in the Clinch River averaged 0.30 percent of the MPC_w.

Radiation Background Measurements

The average background level at the PAM stations during 1977 was 8.3 μR/hr, or 73 mR/yr.

Soil and Grass Samples

Seventeen soil samples were collected and analyzed for plutonium and uranium. Plutonium-239 content ranged from 0.95×10^{-8} μCi/g to 4.4×10^{-8} μCi/g, and the Uranium-235 content ranged from 1.5×10^{-8} μCi/g to 9.0×10^{-8} μCi/g.

Seventeen grass samples were collected and analyzed for plutonium and uranium. Plutonium-239 content ranged from 0.23 x 10^{-8} μCi/g to 2.1 x 10^{-8} μCi/g, and the Uranium-235 content ranged from 0.23 x 10^{-8} μCi/g to 1.4 x 10^{-8} μCi/g.

RADIATION AND SAFETY SURVEYS

Laboratory Operations Monitoring

During 1977, the Radiation and Safety Surveys personnel continued to assist the operating groups in keeping contamination, air concentration, and personnel exposure levels below the established maximum permissible levels. They assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory.

Radiation Incidents

Fifteen radiation incidents involving radioactive materials were recorded during 1977. This compares with 17 incidents which occurred in 1976.

Laundry Monitoring

Of the 483,000 articles of wearing apparel monitored during 1977, about five percent were found contaminated.

INDUSTRIAL SAFETY AND SPECIAL PROJECTS

Accident Analysis

There was only one Disabling Injury experienced at ORNL in 1977, a frequency rate of 0.12. The frequency rate for 1976 was 0.13. The Serious Injury frequency rate for 1977 was 1.60, as based on the new OSHA system for recording injuries and illness (RII). The frequency rate for 1976 was 1.33.

Summary of Disabling Injuries

A total of 70 days were lost or charged for the one Disabling Injury. The employee will probably suffer a permanent-partial disability.

Safety Awards

The National Safety Council Award of Honor and the Union Carbide Corporation Award of Distinguished Safety Performance were earned by the Laboratory in 1977.

3.0 RADIATION MONITORING

3.1 Personnel Monitoring

All persons who enter Laboratory areas where there is a likelihood of exposure to radiation or radioactive materials are monitored for the kinds of exposure they are likely to sustain. External radiation dosimetry is accomplished mainly by means of badge-meters, pocket ion chambers, and hand exposure meters. Internal deposition is determined from bioassays and *in vivo* counting.

3.1.1 Dose Analysis Summary, 1977

(a) External Exposures - No employee received a whole body radiation dose which exceeded the standards for radiation protection, DOE Manual Chapter 0524. The maximum whole body dose[1] sustained by an employee was about 3.6 rem or 72 percent of the applicable standard (5 rem). The range of doses to persons using ORNL badge-meters is shown in Table 3.1.1, page 9.

As of December 31, 1977, no employee had a cumulative whole body dose which was greater than the applicable standard based on the age proration formula 5(N-18), Table 3.1.2, page 9. No employee has an average annual dose that exceeds five rem per year of employment, Table 3.1.3, page 9. The greatest cumulative whole body dose received by an employee was approximately 108 rem. This was accrued over an employment period of about 33 years and represents an average of about 3.3 rem per year.

The greatest cumulative dose to the skin of the whole body received by an employee during 1977 was about 5 rem or 33 percent of the applicable standard (15 rem).

The maximum cumulative hand dose recorded during 1977 was about 14 rem or 19 percent of the applicable standard (75 rem).

The average of the 10 greatest whole body dose to ORNL employees for each of the years 1973 through 1977 is shown in Table 3.1.4, page 10. The maximum individual dose for each of those years is also shown.

(b) Internal Exposures - During 1977 only two employees excreted actinide elements at levels indicative of new intakes which could result in as much as one-half a maximum permissible body burden (MPBB). The nuclide involved was ^{239}Pu, and in both cases the rapid decrease in the excretion demonstrated that the intake had occurred less than thirty days prior to the first elevated sample and that the resultant systemic deposition was less than 10% of the MPBB.

---

[1] In this report the use of term "dose" means "dose equivalent".

There was only one case of ^{90}Sr excretion for which the level warranted extended follow-up. Evaluation of the excretion curve showed that the intake was not more than 1% of the MPBB. There were no other cases of internal exposure during the year for which the deposition of radioactive material averaged as much as one-fourth the maximum permissible organ burden for the year.

3.1.2 External Dose Techniques

(a) Badge-Meters - Photobadge meters are issued to all employees and to nonemployees who are authorized to have frequent access to ORNL facilities. Temporary meters are issued to casual visitors.

All badge-meters are equipped with nuclear accident metering devices and beta-gamma sensitive films. Various complements of TLD's, according to potential for radiation exposure, are included in photobadge meters. NTA films are included in the badges of those who are likely to be exposed to fast neutrons.

Badge-meters of employees are routinely exchanged and processed each calendar quarter, or more frequently if required for exposure control. Meters issued to visitors are processed as may be required for monitoring purposes.

(b) Pocket Meters - Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL. A pair of pocket meters is carried for the duration of a work shift by persons who work in an area where the potential for an exposure of 20 mR or more exists during the work shift. Pocket meter pairs are processed each day by Health Physics technicians, and readings of 20 mR or more are reported daily to supervision. Pocket meter readings are used for estimating integrated exposure and as a basis for badge-meter processing during a calendar quarter.

(c) Hand Exposure Meters - Hand exposure meters are TLD-loaded finger rings. Hand exposure meters are issued to persons for use during operations where it is likely that the hand dose may exceed 1 rem during the week. They are issued and collected by Radiation and Safety Surveys personnel who determine the need for this type of monitoring and arrange for a processing schedule.

(d) Metering Résumé - Shown in Table 3.1.5, page 11, are the quantities of personnel metering devices used and processed during 1977. The number of dosimeters processed is less than the number issued, because those which were issued for accident dosimetry only were not processed unless there was a likelihood of exposure.

3.1.3 Internal Dose Techniques

(a) Bioassay - Urine and fecal samples are analyzed for the purpose of making internal exposure determinations. The frequency of sampling and the type of radiochemical analysis performed is based upon each specific radioisotope and the intake potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible; and only quantitative analyses for predetermined isotopes are performed routinely.

In most cases, bioassay data require interpretation to determine the dose to the person; computer programs are used for evaluation of extensive data on urinary excretion of ^{239}Pu. An estimate of dose is made for all cases in which it appears that one-fourth of a body burden averaged over a calendar year may be exceeded.

The analyses performed by the Industrial Safety and Applied Health Physics radiochemical lab during 1977 are summarized in Table 3.1.6, page 12.

(b) Whole Body Counter - The Whole Body Counter (an *in vivo* gamma spectrometer) may be used for estimating internally deposited quantities of most radionuclides which emit photons.

During calendar year 1977 there were 291 whole body, thorax and wound counts. No counts showed as much as one-half of a maximum permissible lung burden (MPLB), but counts of eight employees corresponded to levels of 15 to 25% of a MPLB of ^{239}Pu and ^{241}Am. (This is below the minimum required for reliable measurement of ^{239}Pu.) Four of the common radionuclides (^{137}Cs, ^{60}Co, ^{153}Gd and ^{109}Cd) were measured at levels of less than 15% MPLB in eight employees. Two isotopes (^{125}I and ^{123}Te) were observed for the first time in four employees, all at levels of less than 25% MPLB.

(c) Counting Facility - The counting facility determines radioactivity content of samples submitted by the Industrial Safety and Applied Health Physics sections. A summary of analyses is in Table 3.1.7, page 13.

3.1.4 Reports

Routine reports of personnel monitoring data are prepared and distributed to divisional supervision and to the Industrial Safety and Applied Health Physics staff.

(a) Pocket Meter Data - A report is prepared daily of the names, ORNL division, and readings for pocket meters which were 20 mR or greater during the previous 24 hours.

A computer-prepared report, which includes all pocket meter data for the previous week and summary data for the calendar quarter, is published and distributed weekly.

(b) External Dosimetry Data - A computer-prepared report, which includes data of recorded skin dose and whole body dose for the previous calendar quarter and totals for the current year, is published and distributed quarterly.

(c) Bioassay Data - A computer-prepared report, which includes data of sample status and results for the previous week, is published and distributed weekly. A quarterly and an annual report of results are prepared and distributed also.

(d) Whole Body Counter Data - Preliminary results of analysis are reported on a card form soon after counting is done. A computer-prepared report, is published and distributed quarterly and annually.

3.1.5 Records

Permanent records of personnel monitoring data are maintained for each person who is assigned an ORNL photobadge meter.

3.2 Health Physics Instrumentation

The Industrial Safety and Applied Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the selection of electronic radiation monitoring instruments used in the ORNL health physics program. Normally, the Industrial Safety and Applied Health Physics Division is responsible for determining the need for new instrument types and modifications to existing types, for specifying the health physics design requirements, and for approval of the design. The Industrial Safety and Applied Health Physics Division is responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated and maintained by Industrial Safety and Applied Health Physics Division personnel.

3.2.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments; the second class includes the stationary instruments that are AC powered. Portable instruments are assigned and issued to the Radiation and Safety Surveys complexes. Stationary instruments are the property of the ORNL division which has the monitoring responsibility in the area in which the instrument is located. Table 3.2.1, page 14. lists portable instruments assigned at the end of 1977; Table 3.2.2, page 14, lists stationary instruments in use at the end of 1977.

Inventory and service summaries for health physics instruments are prepared on an IBM 360. These computer-programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements.

The allocation of stationary health physics monitoring instruments by division is shown in Table 3.2.3, page 15.

3.2.2 Calibration Facility

The Industrial Safety and Applied Health Physics Division maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Industrial Safety and Applied Health Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data on all portable health physics instruments.

Portable instruments should be serviced (1) whenever repairs are needed, (2) at least once every two months for those which have replacement-type batteries, and (3) at least once every three months for those instruments which have "permanent" (rechargeable) batteries. The number of calibrations of portable instruments for 1977 is shown in Table 3.2.4, page 16.

3.3 Developments

3.3.1 Bioassay

The development of excretion and retention functions for internally deposited ^{244}Cm from the urinary excretion of six employees exposed in earlier years was continued. Mathematical curve-fitting revealed that the excretion by the four employees exposed via inhalation was slightly different from the function developed for the two subjects in which intake was via skin wounds. The two latter cases conformed to the function $E^2 = 12.03\, e^{-1.038t} + 13.25t^{-1.164}$ (t in days) within an accuracy consistent with that of the chemical analysis itself. If the latter term can be resolved into a series of exponentials from animal data, simple integration will reveal the initial intake and the systemic burden at any time.

The excretion from the inhalation cases corresponds to a single intake followed by multiple increments from decreasing minor intakes. This is the behavior to be expected from inhalation of moderately soluble material and total systemic deposition can be calculated from the series of exponentials described above, treating the residue in the lungs as an exponentially decreasing pool. Analysis of these excretion data is continuing.

3.3.2 Installation of a Computer-Based Whole Body Counting System

The ORNL Whole Body Counter has had a Nuclear Data ND 6620 computer-based data acquisition and processing system in routine operation

---

[2]E is the fraction remaining at time t.

since May 1977. Addition of in-house data processing capability has allowed the facility to be much more efficient in spectral analysis and file maintenance. Integration with our various detection systems is now complete and the operation is proceeding rather smoothly.

3.3.3 Continued Development of Improved Techniques for In Vivo Detection of the Actinide Elements

A major effort is continuing at the Whole Body Counter to analyze the suitability of current radionuclide analysis techniques and to develop improved analytical and experimental methods for in vivo detection of the actinide elements, particularly ^{238,239}Pu and ^{244}Cm. These research efforts may be summarized as follows:

(a) Monte Carlo Simulation of X-Ray Transport in a Heterogeneous MIRD Phantom - Photon exit spectra arising from various distributions of ^{239}Pu in the lungs of a standard MIRD phantom have been investigated in conjunction with G. G. Warner of the Computer Sciences Division and C. E. Bemis, Jr., of the Chemistry Division. In these studies the transport of uranium Lα (13.615 KeV), Lβ (17.22 KeV) and Lγ (20.167 KeV) photons has been evaluated in addition to the transport of the ^{241}Am 59.5 KeV gamma photon. Over 31 million case histories were generated using the IBM 360/91 system. The front and rear escape probabilities for an L X-ray point source in the lung are given from these studies by:

$$f_{front} = 0.21\ e^{-1.42\ (\mu_s X_s + \mu_L X_L)}$$

$$f_{rear} = 0.25\ e^{-1.59\ (\mu_s X_s + \mu_L X_L)}$$

where X_s and X_L are the straight line thicknesses of soft tissue and lung, and μ_s, μ_L are the respective attenuation coefficients. These data can also be interpreted in terms of the effective soft tissue attenuation. The effective soft tissue thickness for chest counting (ESTT) has been defined[3] to be that thickness of a tissue equivalent absorber which, when placed over a point source in a defined geometry, yields the same counting rate as that observed from the same activity in vivo. From our data on a uniform lung distribution and from the regression equations above, the ESTT for front Pu counting is found to be 5.1 ± 0.6 cm. This value agrees well with the average ESTT of 5.0 ± 0.98 cm taken from the ^{103}Pd studies of Rundo.[3]

(b) Continued Investigation of the Use of Large, Intrinsic Ge Arrays for In Vivo Analysis of Pu - This effort has involved an extensive experimental and theoretical study of the use of germanium detector arrays for improved Pu counting. The investigation has now essentially been completed and the proposed system is under preliminary bid by two major detector companies. It appears feasible that the new unit can be implemented by early FY 1979.

[3] J. Rundo, K. Rundran and B. T. Taylor, Health Phys. 17, 155 (1969).

Table 3.1.1 Dose Data Summary for Laboratory Population Involving Exposure to Whole Body Radiation--1977

Group	Dose Range (Rem)							Total
	0-0.1	0.1-1	1-2	2-3	3-4	4-5	5 up	
ORNL Employees	5,763	369	34	14	3	0	0	6,183
ORNL-Monitored Non-Employees	91	10	0	0	0	0	0	101
TOTAL	5,854	379	34	14	3	0	.0	6,284

Table 3.1.2 Average Rem Per Year Since Age 18--1977

Group	Dose Range							Total
	0-0.1	0.1-1	1-2	2-3	3-4	4-5	5 up	
ORNL Employees	5,394	744	37	7	1	0	0	6,183

Table 3.1.3 Average Rem Per Year of Employment at ORNL--1977

Group	Dose Range							Total
	0-0.1	0.1-1	1-2	2-3	3-4	4-5	5 up	
ORNL Employees	5,046	1,027	98	5	7	0	0	6,183

Table 3.1.4 Average of the Ten Highest Whole Body Doses and the Highest Individual Dose by Year.

Year	Average of the Ten Highest Dose (Rem)	The Highest Dose (Rem)
1973	3.12	4.63
1974	2.34	3.58
1975	2.41	2.71
1976	2.68	3.49
1977	2.84	3.62

Table 3.1.5 Personnel Meters Services

	1975	1976	1977
A. Pocket Meter Usage			
1. Number of Pairs Used			
ORNL	80,860	77,272	92,352
CPFF	9,984	8,944	17,836
Total	90,844	86,216	110,188
2. Average Number of Users Per Quarter			
ORNL	806	747	1,200
CPFF	146	194	351
Total	952	941	1,551
B. Meters Processed for Monitoring Data			
1. Beta-Gamma Badge-Meter	23,600	20,190	27,860
2. Neutron Badge-Meter	680	790	800
3. Hand Meter	670	550	700

Table 3.1.6 Radiochemical Lab Analyses - 1977

Radionuclide	Urine	Feces	Milk	Water	Controls
Plutonium, Alpha	423	1		52	67
Transplutonium Alpha	364	2		52	67
Uranium, Alpha	194				20
Strontium, Beta	175		540	52	75
Cesium-137	3				
Tritium	184			104	25
Iodine-131			540		50
Other	25				10
Totals	1,368	3	1,080	260	314

Table 3.1.7 Counting Facility Analyses - 1977

Types of Samples	Number of Samples		Unit Total
	Alpha	Beta	
Facility Monitoring			
Smears	32,039	32,976	65,015
Air Filters	15,455	13,575	29,030
Environs Monitoring			
Air Filters	3,150	3,150	6,300
Fallout		3,054	3,054
Rainwater		727	727
Surface Water		294	294

Table 3.2.1 Portable Instrument Inventory - 1977

Instrument Type	Instruments Added 1977	Instruments Retired 1977	In Service Jan. 1, 1978
G-M Survey Meter	1	29	420
Cutie Pie	3	36	388
Alpha Survey Meter	9	9	279
Neutron Survey Meter	0	3	111
Miscellaneous	0	9	12
TOTAL	13	86	1,210

Table 3.2.2 Inventory of Facility Radiation Monitoring Instruments for the Year - 1977

Instrument Type	Installed During 1977	Retired During 1977	Total Jan. 1, 1978
Air Monitor, Alpha	0	1	109
Air Monitor, Beta	1	5	168
Lab Monitor, Alpha	0	1	188
Lab Monitor, Beta	1	0	215
Monitron	2	1	218
Other	2	3	146
TOTAL	6	11	1,044

Table 3.2.3 Health Physics Facility Monitoring Instruments
Divisional Allocation - 1977

ORNL Division	α Air Monitor	β Air Monitor	α Lab Monitor	β Lab Monitor	Monitron	Other	Total
Analytical Chemistry	8	11	16	18	14	5	72
Chemical Technology	55	53	81	52	56	38	335
Chemistry	7	4	14	13	3	2	43
Metals and Ceramics	11	6	14	5	5	10	51
Operations	15	80	38	78	108	36	355
All Others	13	14	25	49	32	55	188
TOTAL	109	168	188	215	218	146	1,044

Table 3.2.4 Calibrations Facility Résumé -1977

	1977
Beta-Gamma	2,817
Neutron	373
Alpha	927
Personal Dosimeters	3,490
Badge Dosimetry Components	6,200

4.0 ENVIRONMENTAL SURVEILLANCE

The Environmental Surveillance and Evaluation Section of the Industrial Safety and Applied Health Physics Division monitors for airborne radioactivity in the East Tennessee area by the use of three separate monitoring networks. The local air monitoring (LAM) network consists of 23 stations that are positioned relatively close to ORNL operational activities; the perimeter air monitoring (PAM) network consists of nine stations located on the perimeter of the DOE-controlled area and provides data for evaluating the impact of all Oak Ridge operations on the immediate environment; and the remote air monitoring (RAM) network consists of eight stations located outside the DOE-controlled area at distances of 12 to 75 miles from ORNL (see Figures 4.01-4.04). The monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques, (2) radioparticulate fallout material by impingement on gummed paper trays, (3) rainwater for measurement of fallout occurring as rainout, and (4) radioiodine using charcoal cartridges.

Low-level radioactive liquid wastes originating from ORNL operations are discharged, after treatment, to White Oak Creek, which is a small tributary of the Clinch River. The radioactive content of White Oak Creek discharge is determined at White Oak Dam, which is the last control point along the stream prior to the entry of White Oak Creek into the Clinch River. Water samples are collected at several locations in the Clinch River, beginning at a point above the entry of the wastes into the river and ending at Center's Ferry near Kingston, Tennessee, the nearest population center downstream (Figure 4.0.5).

Samples of White Oak Creek effluent are collected at White Oak Dam by a continuous proportional sampler and analyzed weekly for gross beta activity as a control measure and as a means of evaluating the gross concentration of radioactivity entering the Clinch River. Portions of the weekly samples are composited into monthly samples for detailed analyses by gamma spectrometric and wet-chemical techniques. The weekly samples are analyzed for transuranic alpha emitters, total strontium, tritium, and iodine-131. The monthly composites are concentrated and analyzed by radiochemical and gamma spectrometric techniques, normally for the following: strontium-90, cesium-137, barium-140, cerium-144, ruthenium-106, zirconium-95, niobium-95, cobalt-60, tritium, plutonium, transplutonium, and gross beta. Calculations are made of the concentrations of radioactivity in the Clinch River at the point of entry of White Oak Creek, using the concentrations measured at White Oak Dam and the dilution provided by the river. To verify the calculated concentrations, two sampling stations are maintained in the Clinch River below the point of entry of the wastes; one at the Oak Ridge Gaseous Diffusion Plant (ORGDP) water intake (Clinch River Mile [CRM] 14.5) and the other at Center's Ferry near Kingston, Tennessee (CRM 4.5). Additional sampling stations are maintained in the Clinch River above the point of entry of the waste at Melton Hill Dam (CRM 23.1) to provide baseline data and at the mouth of White Oak Creek for backup measurements of White Oak Dam station.

The ORGDP water sampling station collects a sample from the Clinch River proportional to the flow in the river near the water intake of the ORGDP water system. The samples are brought into the Laboratory at weekly intervals, and an aliquot is composited for quarterly analysis of tritium. The remaining portion of the sample is passed over anion and cation resins to remove nuclides. At quarterly intervals, the resin columns are eluted, and the eluent is analyzed for gross activity and for individual radionuclides that may be present in significant amounts.

A "grab" sample is collected daily at the Center's Ferry sampling station which is located on the Clinch River at CRM 4.5. The daily grab samples are composited and analyzed on a quarterly basis. The preparation of these samples and the analyses performed are the same as those for the ORGDP water sampling station.

The Melton Hill Dam sampling station collects a sample proportional to the flow of water through the power-generating turbines, which represents all of the discharge from the Dam other than a minor amount discharged in the operation of the locks. Samples are collected from the station at weekly intervals, processed, and analyzed in the same manner as for the ORGDP water sampling station.

Samples of ORNL potable water are collected daily, composited, and stored. At the end of each quarter, these composites are analyzed radiochemically for ^{90}Sr content and are assayed for long-lived gamma-emitting radionuclides by gamma spectrometry.

Raw milk is collected at 13 sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from eight stations located outside the DOE-controlled area within a 20-mile radius of ORNL (Figure 4.0.6). Samples are collected every five weeks from the five remaining stations located more remotely with respect to Oak Ridge operations out to distances of about 50 miles (Figure 4.0.7). The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of effluents from ORNL operations; second, samples collected remote to the immediate vicinity of ORNL provide background data which are essential in establishing a proper index from which releases of radioactive materials originating from Oak Ridge operations may be evaluated. The milk samples are analyzed by radiochemical techniques for strontium-90 and iodine-131. The minimum detectable concentrations of strontium-90 and iodine-131 in milk are 0.5 pCi/liter and 0.45 pCi/liter, respectively.

External gamma radiation background measurements are made routinely at the local and perimeter air monitoring stations, at one station located near Melton Hill Dam and at the remote monitoring stations; measurements are made using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations and Melton Hill Dam are collected and analyzed monthly. Those at local and remote stations are collected and analyzed semi-annally.

External gamma radiation measurements are also made routinely along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream (Figure 4.0.8). These measurements were used to evaluate gamma radiation levels resulting from ORNL liquid effluent releases and "sky shine" from an experimental ^{137}Cs plot located near the river bank. Radiation measurements were made using lithium fluoride thermoluminescent dosimeters suspended one meter above the ground surface.

Various species of fish, which are commonly caught and eaten, in eastern Tennessee, are taken from the Clinch River during the spring and summer of each year. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometric and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Soil and grass samples are collected annually from locations near the PAM and RAM stations. Ten samples, approximately 8 cm in diameter and 8 cm thick, are collected from five 400 cm^2 plots at each location, composited, and analyzed by gamma spectroscopy, and radiochemical techniques for uranium, plutonium, and various other radioisotopes.

4.1 Atmospheric Monitoring

4.1.1 Air Concentrations

The average concentrations of alpha radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1977 were as follows:

Network	Concentration (μCi/cc)
LAM	1.9×10^{-15}
PAM	1.1×10^{-15}
RAM	0.9×10^{-15}

All networks are less than 0.1 percent of 4×10^{-12} μCi/cc, the MPC_a for a mixture of uranium isotopes in an uncontrolled area. The values for each station are given in Table 4.1.0.

The average concentrations of beta radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1977, were as follows:

Network	Concentration (μCi/cc)
LAM	6.2×10^{-14}
PAM	4.3×10^{-14}
RAM	4.9×10^{-14}

The LAM network value of 6.2×10^{-14} μCi/cc is less than 0.003 percent of the $MPCU_a$[4] based on occupational exposure of 3×10^{-9} μCi/cc. Both the PAM and RAM network values represent < 0.05 percent of the $MPCU_a$ of 1×10^{-10} μCi/cc applicable to releases to uncontrolled areas. A tabulation of data for each station in each network is given in Table 4.1.1. The weekly values for each network are illustrated in Table 4.1.2.

The values measured for 1977 are higher than those for 1976 by 35%, 48%, and 88% for the LAM, PAM, and RAM networks respectively.

4.1.2 Fallout (Gummed Paper Technique)

The average activity from radioparticulate fallout measured for 1977 was higher than those for 1976 by a factor of ∿ 80% and 50%, respectively, for the LAM and PAM networks. The average activity and number of particles per square foot are shown in Table 4.1.3.

4.1.3 Rainout (Gross Analysis of Rainwater)

The average concentration of beta radioactivity in rain water collected from the three networks during 1977 was as follows:

Network	Concentration (μCi/ml)
LAM	3.9×10^{-8}
PAM	3.9×10^{-8}
RAM	5.3×10^{-8}

The average concentrations of beta radioactivity measured for 1977 were approximately twice the concentrations measured in 1976 for the three networks. The average concentration measured at each station within each network is presented in Table 4.1.4. The average concentration for each network for each week is given in Table 4.1.5.

4.1.4 Atmospheric Radioiodine (Charcoal Cartridge Technique)

Atmospheric iodine sampled at the perimeter stations averaged 0.7×10^{-14} μCi/cc during 1977. This average represents < 0.01 percent of the maximum permissible concentration of 1×10^{-10} μCi/cc applicable to inhalation of ^{131}I released to uncontrolled areas. The maximum concentration observed for one week was 2.0×10^{-14} μCi/cc.

The average radioiodine concentration at the local stations was 2.5×10^{-14} μCi/cc. This concentration is < 0.01 percent of the maximum permissible concentration for inhalation by occupational personnel. The maximum concentration for one week was 6.2×10^{-14} μCi/cc.

---

[4]The $MPCU_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. DOE Manual Chapter 0524, Appendix, Annex 1, gives exposure values applicable to various mixtures of radionuclides and establishes guidelines for deriving the $MPCU_a$.

Table 4.1.6 presents the ^{131}I weekly average concentration data for both the local area (LAM) and the perimeter area (PAM) air monitoring networks. The weekly average ^{131}I concentration in air measured by stations in the LAM and PAM networks are given in Table 4.1.7.

The results of the specific radionuclide analyses of the filters from the three networks are given in Table 4.1.8.

4.1.5 Milk Analysis

The yearly average and maximum concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 4.1.9 and 4.1.10. If one assumes the average intake of milk per individual to be one liter per day, the concentrations of ^{131}I in milk collected near ORNL and in milk collected more remotely from ORNL are within FRC Range I. The concentrations of ^{90}Sr in milk from both the immediate and remote environs of ORNL are also within FRC Range I.

The concentration of ^{131}I in milk is very sensitive to atmospheric weapons testing. This is demonstrated in Figure 4.0.9 which shows the weekly average ^{131}I concentrations of the eight local milk stations following the Chinese atomic-bomb explosion on September 17, 1977. The rapid rise and fall of the levels can be noted.

The concentration of ^{90}Sr in milk varies with locations; part of the variation has been found to result from differences in farming methods. Pastureland that is not fertilized and is overgrazed (a not too uncommon practice in this area) apparently results in a higher than normal concentration of ^{90}Sr in milk from cows pastured on this land.

4.1.6 ORNL Stack Releases

The radionuclide releases from ORNL stacks are summarized in Table 4.1.11.

4.2 Water Monitoring

4.2.1 White Oak Lake Waters

Yearly discharges of specific radionuclides to the Clinch River, 1968 through 1977, are shown in Table 4.2.1.

The calculated average concentrations of the significant radionuclides in the Clinch River at Clinch River Mile (CRM) 20.8 (the point of entry of White Oak Creek into the river) are presented in Table 4.2.2. The concentration did not exceed 1% of MPC_w for any month during 1977 (Table 4.2.3).

The annual average percent MPC_w of beta emitters, other than tritium in the Clinch River, 1968 through 1977, is given in Table 4.2.4. Table 4.2.5 lists the annual average percent MPC_w of tritium in the Clinch River, 1968 through 1977.

4.2.2 Clinch River Water

The measured average concentrations and the percent of MPC_w of radionuclides in the Clinch River at Melton Hill Dam (CRM 23.1), about three miles upstream, at Gallaher (CRM 14.5), about six miles downstream, and at Center's Ferry (CRM 4.5), about 16 miles downstream from the entry of White Oak Creek, are given in Table 4.2.2.

4.2.3 Potable Water

The average concentrations of ^{90}Sr in potable water at ORNL during 1977 were as follows:

Quarter Number	Concentration of ^{90}Sr (μCi/ml)
1	9.0×10^{-11}
2	18.0×10^{-11}
3	14.0×10^{-11}
4	5.0×10^{-11}
Average for Year	12.0×10^{-11}

The average value of 12.0×10^{-11} represents < 0.1 percent of the MPC_w for drinking water applicable to individuals in the general population.

4.2.4 Clinch River Fish

The results of the analysis of fish samples are tabulated in pCi/kg of wet weight (Table 4.2.6) for each radionuclide of significance. An estimate of man's intake of radionuclides from eating the fish is made by assuming an annual rate of fish consumption of 37 pounds. An estimated percentage of maximum permissible intake is calculated by assuming a maximum permissible intake of fish to be comparable to a daily intake of 2.2 liters of water containing the MPC_w of these radionuclides for a period of one year. Stable elements in Clinch River fish are given in Table 4.2.7.

4.3 Radiation Background Measurements

Data on the average external gamma radiation background rates are given in Tables 4.3.1 and 4.3.2. The slight difference between the average levels in the perimeter and remote environs is considered to be within the variation in background levels normally experienced in East Tennessee which is dependent upon elevation, topography, and geological character of surrounding soil.[5]

---

[5]T. W. Oakes, K. E. Shank, and C. E. Easterly, "Natural and Man-Made Radionuclide Concentrations in Tennessee Soil," in Proceedings of the Health Physics Society Tenth Midyear Topical Symposium, Saratoga Springs, New York, October 11-13, 1976, pp. 322-333.

The average external gamma radiation levels along the bank of the Clinch River adjacent to an experimental cesium field are given in Table 4.3.3.

4.4 Soil and Grass Samples

Data on uranium, plutonium, and other radioisotope concentrations in soil and grass samples are given in Table 4.4.1 and 4.4.2. A distribution plot of the uranium in the perimeter and remote soils is shown in Figure 4.0.10; a plot of ^{239}Pu in soils is given in Figure 4.0.11.

4.5 Environmental Monitoring Samples

A listing of environmental monitoring samples processed by type sample, type of analyses, and number of samples is given in Table 4.5.1.

4.6 Calculation of Potential Radiation Dose to the Public

To determine the radiation doses resulting from gaseous discharges from ORNL, the Gaussian plume model developed by Pasquill[6] and Gifford[7] was incorporated into a computer program. The effluents were assumed to occur from a single 250-foot stack, and meteorological data collected at the ORNL site were used.

The average total body dose rate to an Oak Ridge resident from ORNL gaseous effluents was calculated to be .04 $\pm$ 150% mrem/yr, which is < .01 percent of the allowable standard. The cumulative whole body dose to the population within a 50-mile radius of ORNL, resulting from 1977 atmospheric effluents, was calculated to be 4.7 $\pm$ 150% man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population from natural background radiation. The large errors connected with these numbers are the result of the large uncertainties associated with the meterological data.

The point of maximum potential exposure to an individual on the site boundary is located along the bank of the Clinch River adjacent to an experimental cesium field and is due primarily to "sky shine" from the field. A maximum potential whole body dose rate of 260 mrem/yr was calculated for this location, assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 52 percent of the allowable standard.[8] This is an atypical exposure location, and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

---

[6] F. Pasquill, Atmospheric Diffusion, D. Van Nostrand Co., Ltd., London, 1962.

[7] F. A. Gifford, Jr., The Problem of Forecasting Dispersion in the Lower Atmosphere, USAEC, ~~DTI, 1962.~~

[8] DOE Manual Chapter 0524.

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated, using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 7.2 mrem/yr, which is 1.4 percent of the allowable standard and represents what is considered a probable upper limit of exposure.

4.7 Quality Assurance at Oak Ridge National Laboratory

The Environmental Surveillance and Evaluation Section at Oak Ridge National Laboratory has initiated a quality assurance program to ensure that a high degree of accuracy and reliability is maintained in its surveillance activities. The program in effect at ORNL consists of quality control of techniques and procedures, and includes the establishement of a detailed written description of all activities pertaining to the Environmental Surveillance and Evaluation Section. This includes:

1. Operating procedures for each activity.
2. Inspection lists of operating and maintenance activities.
3. Check-off frequency lists for all quality assurance steps, such as schedules for equipment inspection and test control.
4. Documentation of compliance of quality assurance procedures.
5. Participation in intra-laboratory and inter-laboratory sample-exchange programs.
6. Evaluation of the adequacy of sample preparation work and data analysis.
7. Identification of the role, responsibilities, and authority of each staff member as related to quality assurance.

A schematic diagram showing a flow chart of this quality assurance program is given in Figure 1, page 63. A more detailed discussion of the ORNL QA program is given in Ref. (1) & (2). The relationship between sample flow, QA program, and impact of failure is shown in Figure 2, page 64.

Role of Management - A strong QA program must include a management system to control operations and specialized techniques to facilitate beneficial decisions. When properly established and implemented, management of the program can enhance the overall QA effort, provide the program framework, and play a meaningful role in its development. Management has many functions frequently identified as planning, organizing, executing, and monitoring which are illustrated in Figure 3, page 65. Proper organization for the flow of information is a key factor in ensuring that corrective action is taken in the proper time frame. The organization for the Environmental Surveillance QA program is linked up with the overall ORNL program as shown in Figure 4, page 66.

Conclusions

Our experience has demonstrated the necessity of a complete quality assurance program for the overall enhancement of environmental monitoring. A quality assurance program provides a mechanism for ensuring efficiency in everyday activities and for keeping current in the latest procedures. Further, the quality assurance approach could be used as a basis for establishing regulatory guides for a monitoring protocol, and regulated facilities would be required to collect and analyze samples in a comparable manner. This type of program would require such facilities to review monitoring procedures and methods more closely, rather than collecting information for the sole purpose of compliance with regulatory guides. Such a program would be beneficial to regulatory agencies by identifying nonessential collection requirements. Realizing that the development of a quality assurance program will initially increase operating expenses for environmental surveillance, we believe that once fully implemented, a well-designed program will be cost effective.

References:

(1) T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Quality Assurance Applied to an Environmental Surveillance Program," Conference Proceedings of the 4th Joint Conference on Sensing of Environmental Pollutants, New Orleans, La., Nov. 6-11, 1977 (226).

(2) T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Quality Assurance Procedures for Environmental Surveillnace at ORNL," ORNL-5186, in preparation.

ORNL–DWG. 66–2218

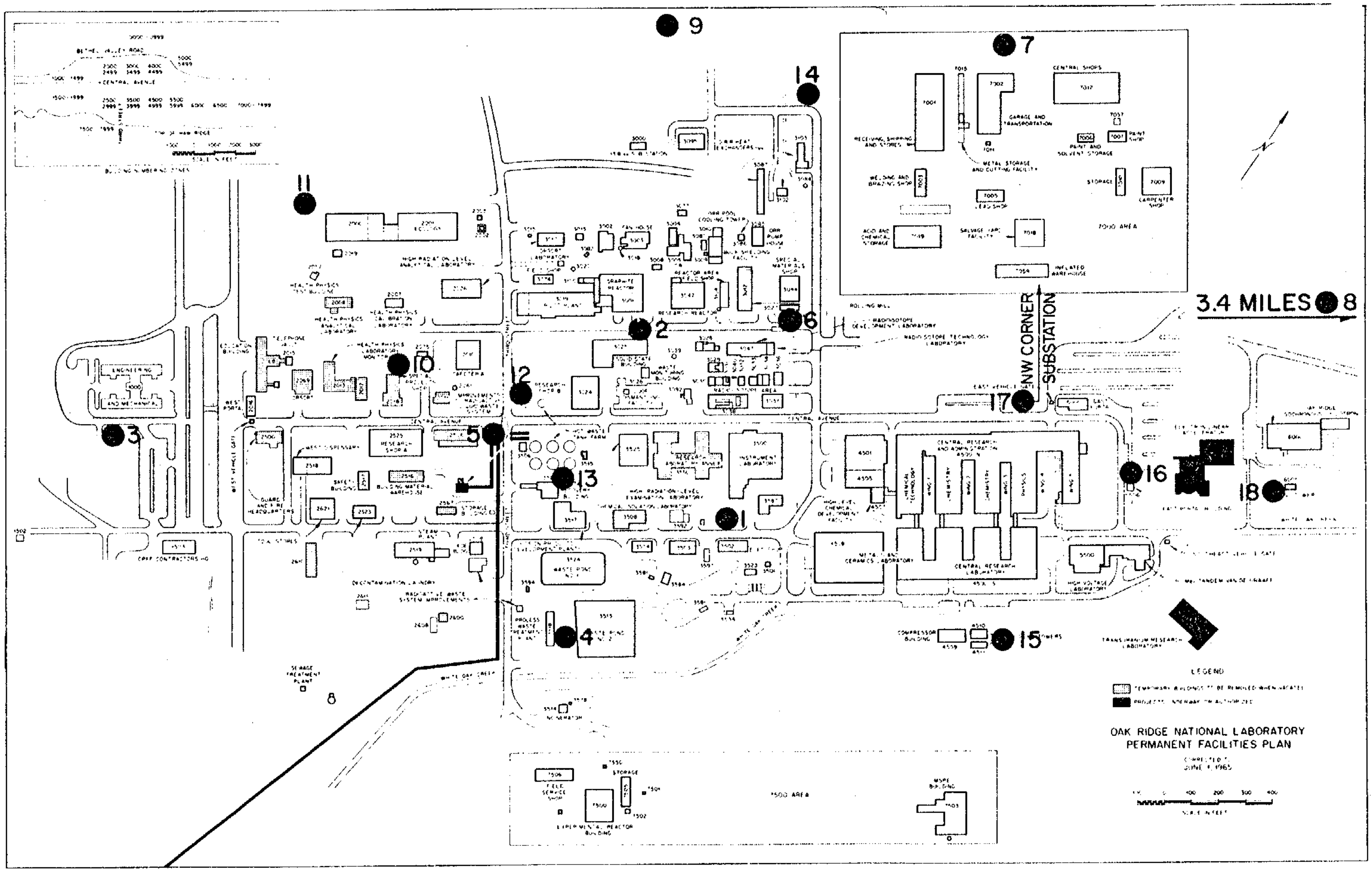


Fig. 4.0.1 Local Air Monitoring (LAM) Network - Bethel Valley

ORNL-DWG. 66-1718

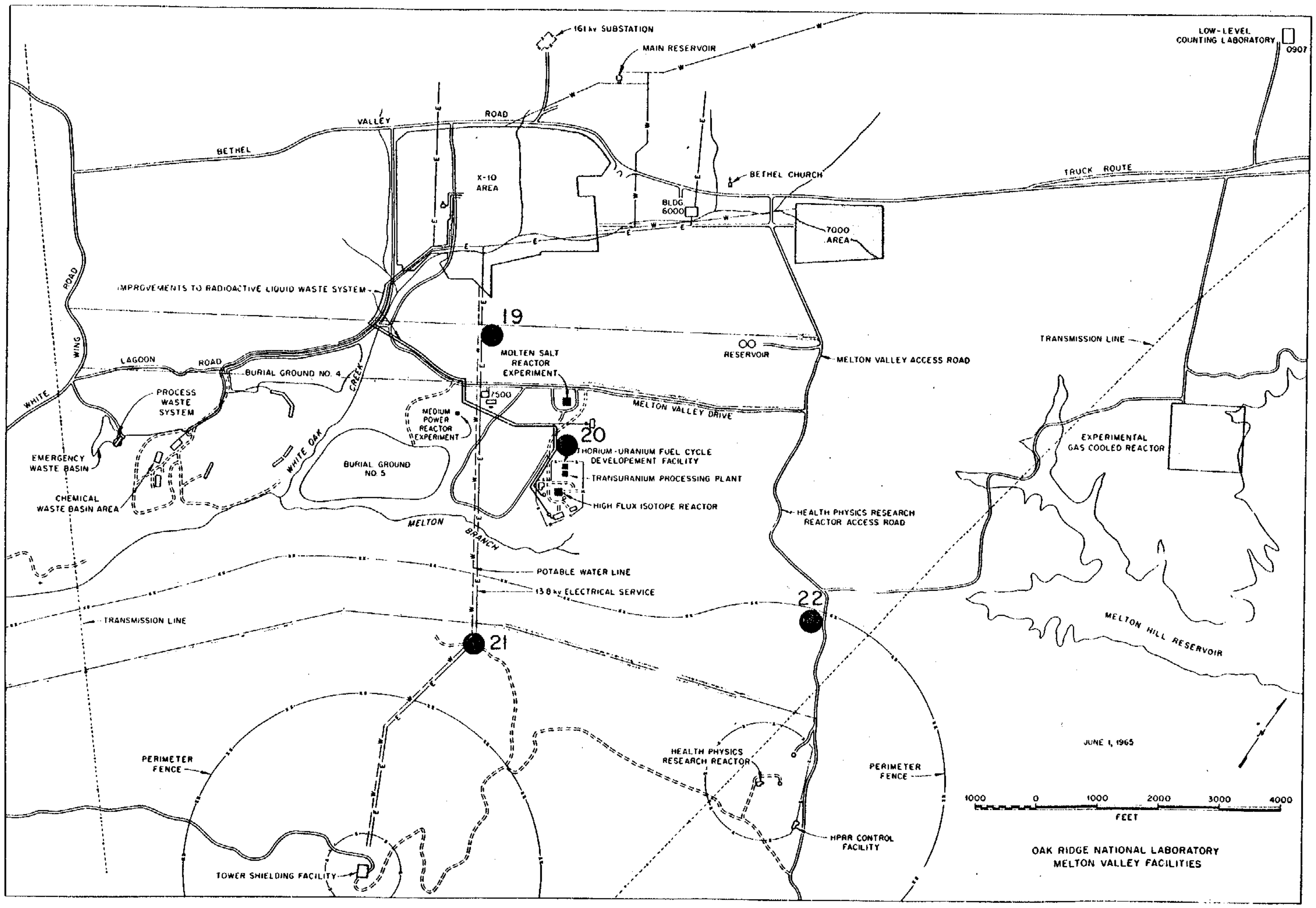


Fig. 4.0.2 Local Air Monitoring (LAM) Network - Outlying Stations

ORNL-DWG. 68-4302

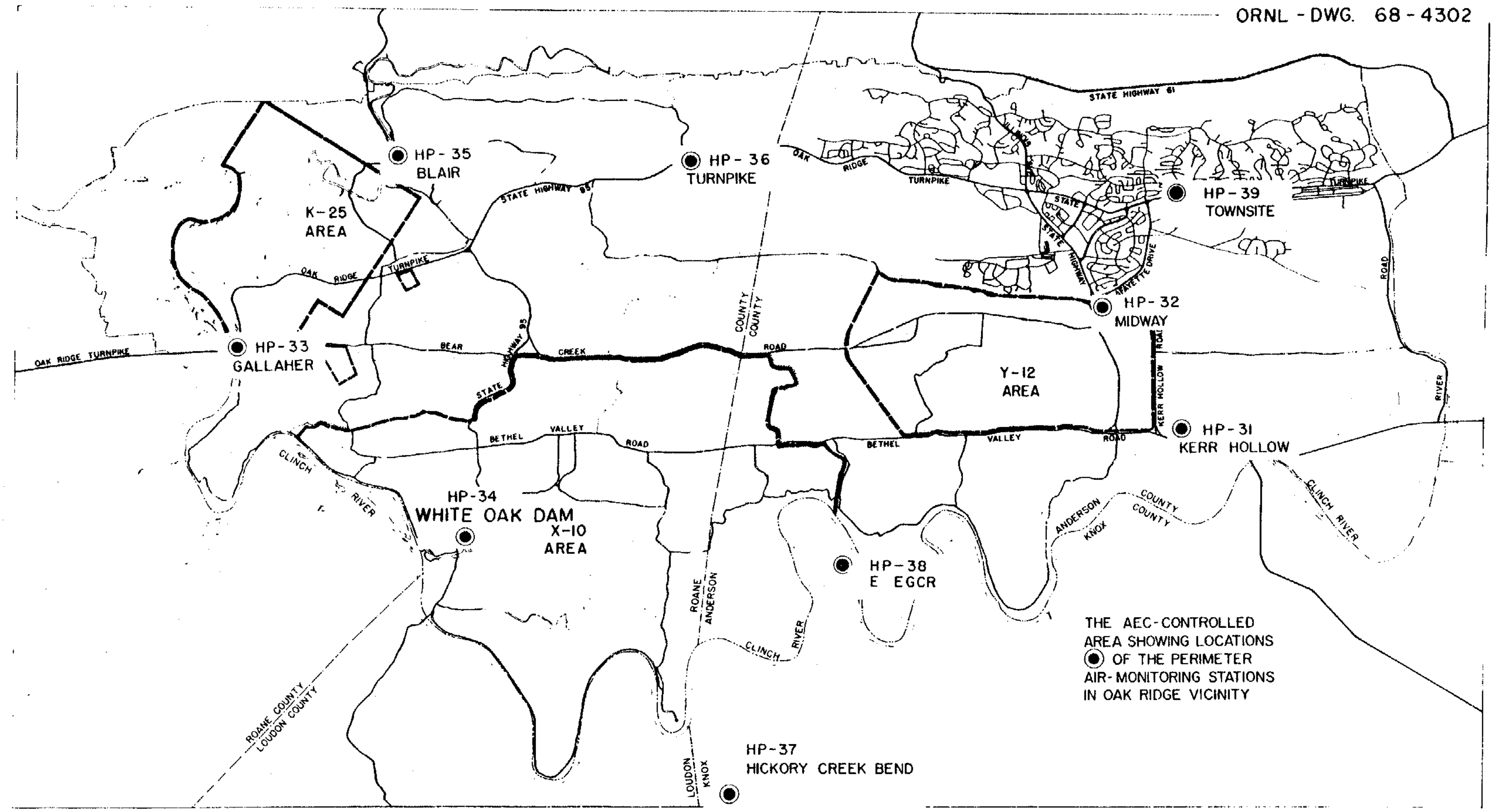


Fig. 4.0.3 Perimeter Air Monitoring (PAM) Network

ORNL-DWG 66-1719

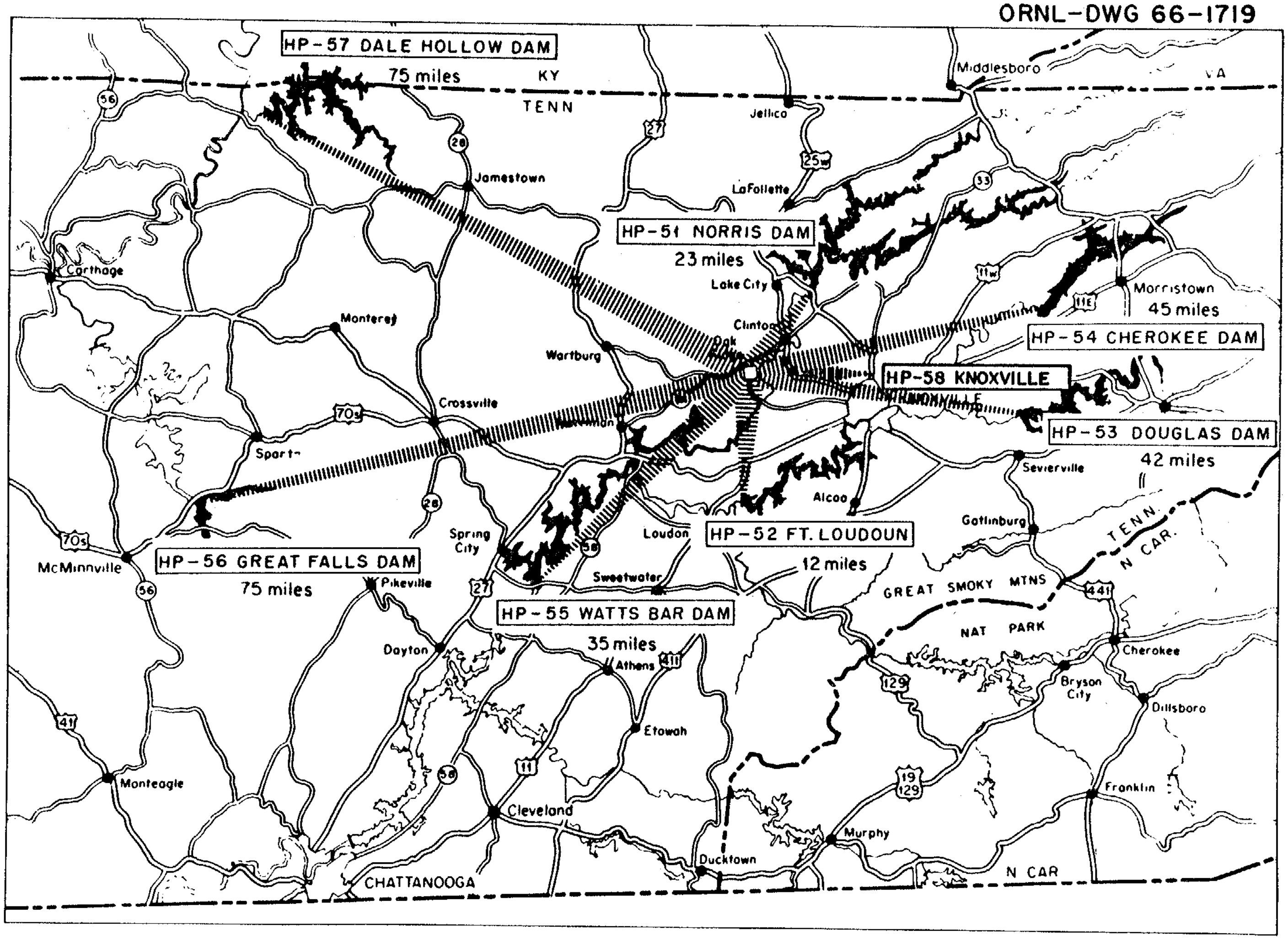


Fig. 4.0.4 Remote Air Monitoring (RAM) Network

ORNL-DWG. 66-2216R

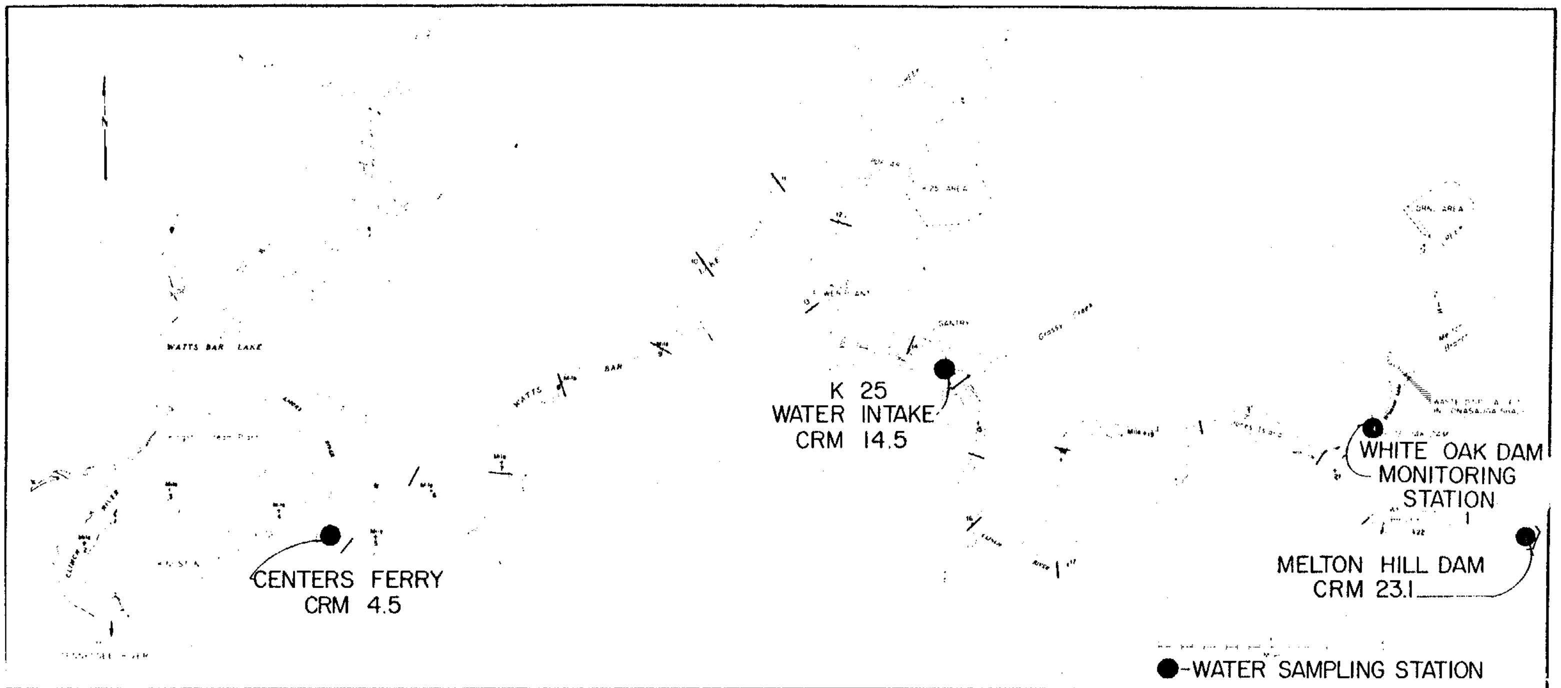


Fig. 4.0.5 Map Showing Water Sampling Locations in the East Tennessee Area

ORNL—DWG. 64-3713

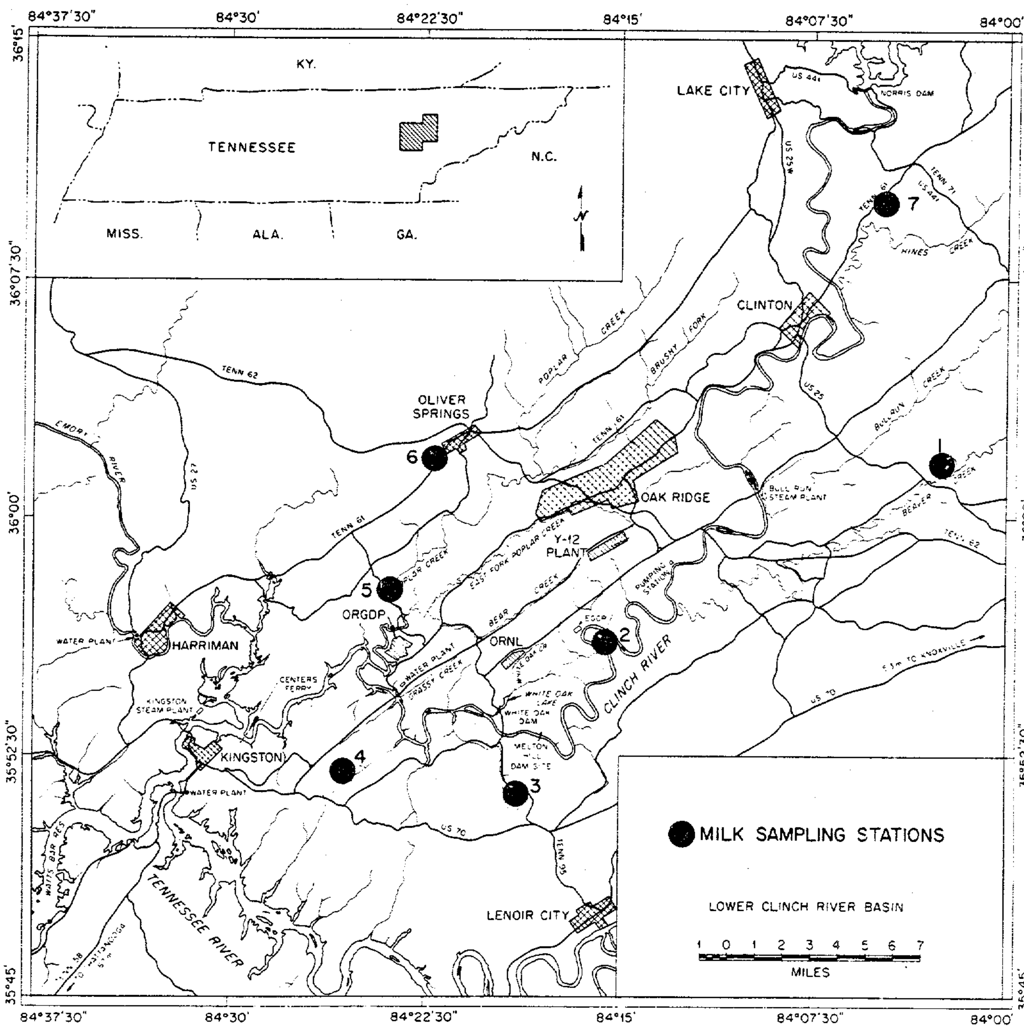


Fig. 4.0.6 Location of Milk Sampling Stations (Within 20-Mile Radius of ORNL)

ORNL DWG 76-12775

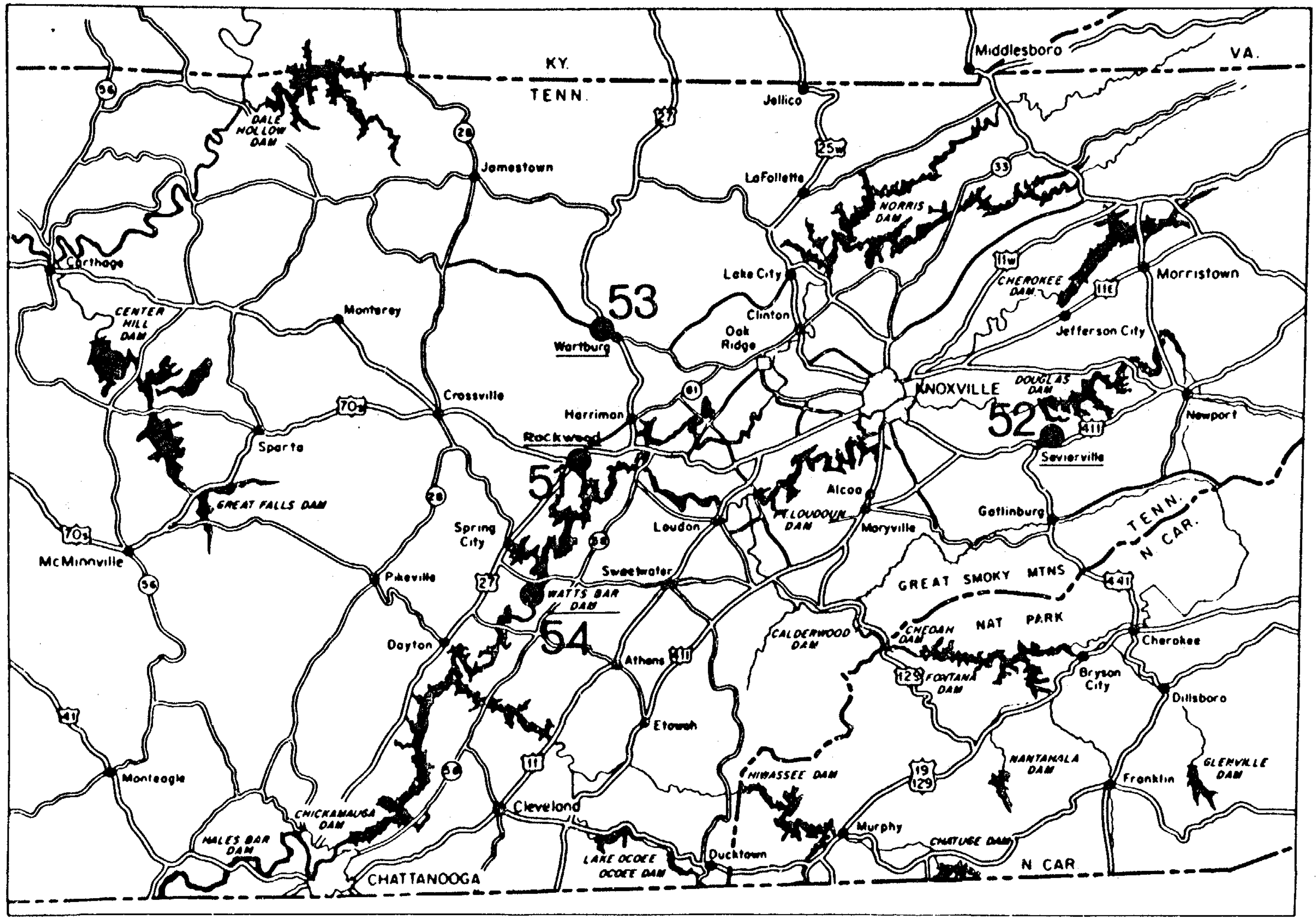


Fig. 4.0.7 Remote Environs Milk Sampling Locations

ORNL DWG 76-12776

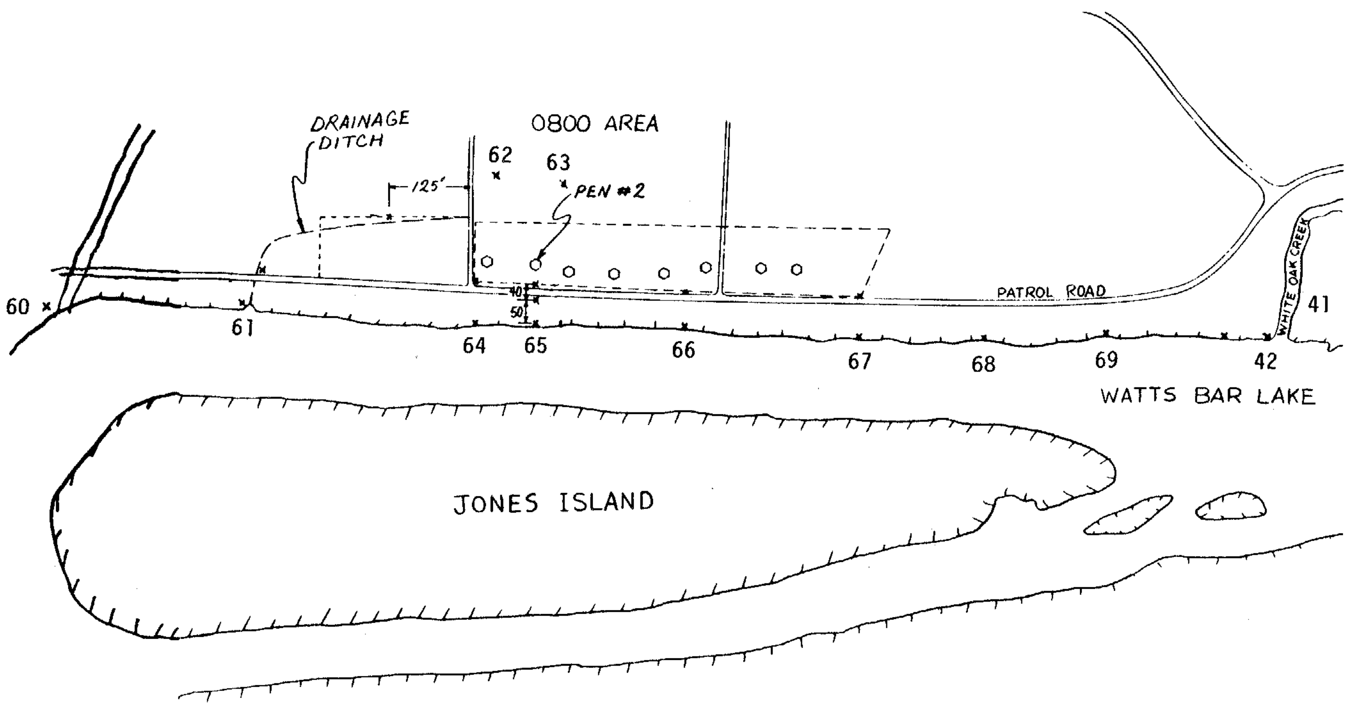


Fig. 4.0.8 Thermoluminescent Dosimeter Locations Along Perimeter of the DOE-Oak Ridge Controlled Area

Table 4.1.0 Concentration of Alpha Radioactivity in Air - 1977 (Filter Paper Data - Yearly Average)

Station Number	Location	Long-Lived Activity 10^{-15} μCi/cc
	Laboratory Area	
HP-1	S 3587	1.5
HP-2	NE 3025	1.9
HP-3	SW 1000	2.1
HP-4	W Settling Basin	2.0
HP-5	E 2506	2.1
HP-6	SW 3027	1.7
HP-7	W 7001	1.9
HP-8	Rock Quarry	1.7
HP-9	N Bethel Valley Road	2.0
HP-10	W 2075	2.2
HP-16	E 4500	2.2
HP-20	HFIR	1.6
HP-23	Walker Branch	1.4
Average		1.9
	Perimeter Area	
HP-31	Kerr Hollow Gate	0.9
HP-32	Midway Gate	1.2
HP-33	Gallaher Gate	1.6
HP-34	White Oak Dam	1.0
HP-35	Blair Gate	1.3
HP-36	Turnpike Gate	1.0
HP-37	Hickory Creek Bend	1.0
HP-38	E EGCR	0.9
HP-39	Townsite	1.1
Average		1.1
	Remote Area	
HP-51	Norris Dam	0.8
HP-52	Loudoun Dam	0.9
HP-53	Douglas Dam	1.0
HP-54	Cherokee Dam	0.7
HP-55	Watts Bar Dam	0.9
HP-56	Great Falls Dam	0.9
HP-57	Dale Hollow Dam	0.8
HP-58	Knoxville	0.9
Average		0.9

Table 4.1.1 Concentration of Beta Radioactivity in Air - 1977
(Filter Paper Data - Yearly Average)

Station Number	Location	Long-Lived Activity 10^{-14} μCi/cc
	Laboratory Area	
HP-1	S 3587	5.9
HP-2	NE 3025	6.3
HP-3	SW 1000	7.1
HP-4	W Settling Basin	5.8
HP-5	E 2506	8.4
HP-6	SW 3027	7.3
HP-7	W 7001	4.7
HP-8	Rock Quarry	6.7
HP-9	N Bethel Valley Road	5.9
HP-10	W 2075	4.7
HP-16	E 4500	6.1
HP-20	HFIR	5.9
HP-23	Walker Branch	5.9
Average		6.2
	Perimeter Area	
HP-31	Kerr Hollow Gate	4.6
HP-32	Midway Gate	4.6
HP-33	Gallaher Gate	2.8
HP-34	White Oak Dam	3.8
HP-35	Blair Gate	5.1
HP-36	Turnpike Gate	5.4
HP-37	Hickory Creek Bend	3.8
HP-38	E EGCR	4.3
HP-39	Townsite	4.6
Average		4.3
	Remote Area	
HP-51	Norris Dam	5.0
HP-52	Loudoun Dam	5.0
HP-53	Douglas Dam	4.4
HP-54	Cherokee Dam	5.4
HP-55	Watts Bar Dam	4.1
HP-56	Great Falls Dam	5.1
HP-57	Dale Hollow Dam	5.9
HP-58	Knoxville	4.6
Average		4.9

Table 4.1.2 Concentration of Beta Radioactivity in Air as Determined from Filter Paper Data - 1977 (System Average - by Weeks)

Week Number	Units of 10^{-14} μCi/cc LAM's	PAM's	RAM's	Week Number	Units of 10^{-14} μCi/cc LAM's	PAM's	RAM's
1	2.3	1.6	1.6	29	8.0	4.8	6.3
2	2.3	1.6	1.3	30	9.1	6.7	7.1
3	2.0	1.2	1.3	31	7.2	3.9	4.6
4	2.0	0.9	0.8	32	4.1	2.3	2.7
5	1.4	0.8	0.8	33	9.2	6.2	6.7
6	2.3	1.3	1.2	34	6.7	3.6	6.2
7	1.6	0.9	0.9	35	5.4	3.3	3.5
8	2.1	1.1	1.3	36	5.5	2.7	3.5
9	5.4	5.3	4.1	37	3.0	1.7	2.5
10	2.8	1.8	2.2	38	8.4	6.3	6.5
11	3.0	3.0	2.9	39	20.6	14.7	14.3
12	4.1	2.7	2.4	40	7.5	4.8	6.3
13	4.4	3.1	4.9	41	6.4	3.3	3.3
14	6.1	4.9	5.0	42	6.9	4.8	6.6
15	8.1	6.5	6.2	43	5.1	3.2	3.6
16	7.5	5.0	5.9	44	4.0	2.3	13.1
17	6.7	5.1	6.1	45	6.0	4.6	3.6
18	9.5	7.5	8.3	46	8.7	3.4	5.2
19	10.9	9.2	10.8	47	2.9	1.7	2.4
20	12.8	8.2	8.8	48	2.7	1.2	2.0
21	5.8	4.5	4.9	49	3.2	1.9	2.1
22	12.7	11.2	9.3	50	3.2	2.1	2.1
23	14.2	10.1	12.5	51	8.6	6.2	5.8
24	6.3	4.4	4.9	52	6.6	6.8	6.0
25	5.2	4.1	4.9				
26	6.9	6.1	5.0				
27	7.2	4.7	6.6				
28	8.7	6.4	6.3	Average	6.2	4.3	4.9

Table 4.1.3 Radioparticulate Fallout - 1977
(Gummed Paper Data - Station Yearly Average)

Station Number	Location	Long-Lived Beta Activity 10^{-4} µCi/ft^2	Total Particles Per Sq. Ft.*
	Laboratory Area		
HP-1	S 3587	0.15	1.2
HP-2	NE 3025	0.13	0.5
HP-3	SW 1000	0.13	0.3
HP-4	W Settling Basin	0.17	0.5
HP-5	E 2506	0.16	0.5
HP-6	SW 3027	0.17	1.8
HP-7	W 7001	0.12	1.0
HP-8	Rock Quarry	0.12	0.3
HP-9	N Bethel Valley Road	0.12	0.5
HP-10	W 2075	0.18	0.5
HP-16	E 4500	0.13	0.5
HP-20	HFIR	0.12	0.4
HP-23	Walker Branch	0.24	0.3
Average		0.15	0.7
	Perimeter Area		
HP-31	Kerr Hollow Gate	0.13	ND**
HP-32	Midway Gate	0.13	ND**
HP-33	Gallaher Gate	0.13	ND**
HP-34	White Oak Dam	0.11	ND**
HP-35	Blair Gate	0.14	ND**
HP-36	Turnpike Gate	0.13	ND**
HP-37	Hickory Creek Bend	0.10	ND**
HP-38	E EGCR	0.12	ND**
HP-39	Townsite	0.13	ND**
Average		0.12	ND**
	Remote Area		
HP-51	Norris Dam	0.13	ND**
HP-52	Loudoun Dam	0.13	ND**
HP-53	Douglas Dam	0.09	ND**
HP-54	Cherokee Dam	0.11	ND**
HP-55	Watts Bar Dam	0.16	ND**
HP-56	Great Falls Dam	0.11	ND**
HP-57	Dale Hollow Dam	0.13	ND**
HP-58	Knoxville	0.11	ND**
Average		0.12	ND**

* Data determined from autoradiograms.
** None Detected.

Table 4.1.4 Concentration of Beta Radioactivity in Rainwater - 1977
(Yearly Average by Stations)

Station Number	Location	Activity in Collected Rainwater 10^{-8} µCi/ml
	Laboratory Area	
HP-7	West 7001	4.0
HP-23	Walker Branch	4.7
Average		4.4
	Perimeter Area	
HP-31	Kerr Hollow Gate	4.5
HP-32	Midway Gate	3.5
HP-33	Gallaher Gate	4.9
HP-34	White Oak Dam	3.7
HP-35	Blair Gate	3.4
HP-36	Turnpike Gate	4.0
HP-37	Hickory Creek Bend	3.0
HP-38	E EGCR	5.0
HP-39	Townsite	3.5
Average		3.9
	Remote Area	
HP-51	Norris Dam	5.8
HP-52	Loudoun Dam	6.2
HP-53	Douglas Dam	5.1
HP-54	Cherokee Dam	5.8
HP-55	Watts Bar Dam	4.8
HP-56	Great Falls Dam	5.6
HP-57	Dale Hollow Dam	5.1
HP-58	Knoxville	4.1
Average		5.3

Table 4.1.5 Weekly Average Concentration of Beta Radioactivity in Rainwater - 1977 (Units of 10^{-8} μCi/ml)

Week Number	LAM's	PAM's	RAM's	Week Number	LAM's	PAM's	RAM's
1	NS*	NS	3.13	27	NS	NS	6.60
2	NS	NS	4.10	28	NS	3.30	6.97
3	1.25	1.46	2.77	29	1.90	3.16	5.12
4	NS	NS	4.00	30	3.55	3.47	5.15
5	1.60	1.33	8.00	31	1.70	2.23	4.83
6	0.70	1.23	5.56	32	1.80	3.85	4.40
7	NS	NS	2.60	33	3.60	2.93	4.15
8	2.15	1.76	1.77	34	2.55	1.78	3.32
9	1.30	3.61	4.52	35	4.55	2.56	6.03
10	3.20	2.91	2.57	36	3.05	1.43	2.77
11	5.15	3.57	5.80	37	0.45	0.94	4.45
12	3.30	3.63	3.40	38	8.90	12.31	11.97
13	3.85	4.22	6.50	39	19.40	16.73	14.52
14	NS	NS	3.85	40	6.10	3.66	5.47
15	NS	NS	NS	41	13.30	9.53	9.80
16	1.85	3.61	4.15	42	NS	NS	0.0
17	8.40	7.42	9.56	43	1.85	1.06	2.77
18	8.70	4.98	7.77	44	4.00	2.42	4.97
19	NS	NS	NS	45	4.00	2.24	5.95
20	5.40	5.32	8.71	46	3.20	2.80	4.49
21	5.90	3.27	8.05	47	3.30	2.34	3.07
22	NS	3.60	3.20	48	3.70	2.83	2.72
23	5.05	5.04	5.51	49	4.40	7.30	4.62
24	6.90	5.37	9.06	50	2.75	3.48	4.25
25	2.76	4.37	6.71	51	1.95	2.06	4.10
26	6.40	3.55	4.89	52	5.15	3.31	7.77
				Average	4.4	3.9	5.3

* No rainfall.

Table 4.1.6 Weekly Concentration of ^{131}I in Air - 1977
(Units of 10^{-14} μCi/cc)

Week Number	LAM's	PAM's	Week Number	LAM's	PAM's
1	2.7	1.2	27	1.8	0.4
2	3.4	1.4	28	2.9	0.4
3	1.7	1.3	29	6.2	0.5
4	3.2	0.6	30	2.0	0.6
5	2.6	1.1	31	3.9	0.5
6	2.4	0.6	32	3.3	0.4
7	1.7	0.6	33	2.3	0.7
8	1.3	0.3	34	5.0	0.6
9	2.1	0.7	35	5.0	0.7
10	1.2	0.5	36	3.5	0.9
11	1.6	0.5	37	1.5	0.4
12	2.3	0.4	38	1.9	1.1
13	2.3	0.5	39	4.0	2.0
14	2.9	0.6	40	1.6	0.7
15	2.6	0.4	41	2.4	0.7
16	1.8	0.7	42	2.2	1.1
17	1.8	0.7	43	1.9	0.6
18	1.5	0.2	44	2.0	0.7
19	2.8	0.7	45	3.5	0.6
20	1.5	0.3	46	1.9	0.5
21	0.9	0.2	47	1.1	0.3
22	1.1	0.5	48	1.5	0.8
23	2.3	0.6	49	5.9	1.1
24	1.8	0.5	50	2.1	0.7
25	3.5	0.4	51	4.3	1.2
26	1.5	0.6	52	3.4	1.9
			Average	2.5	0.7

Table 4.1.7 Concentration of ^{131}I in Air - 1977
(Weekly Average by Stations)

Station Number	Location	Activity in Air 10^{-14} μCi/cc
	Laboratory Area	
HP-3	SW 1000	2.9
HP-4	W Settling Basin	2.0
HP-6	SW 3027	3.2
HP-7	W 7001	2.3
HP-8	Rock Quarry	2.2
HP-9	N Bethel Valley Road	2.5
HP-10	W 2075	4.4
HP-16	E 4500	2.6
HP-20	HFIR	1.6
HP-23	Walker Branch	1.3
Average		2.5
	Perimeter Area	
HP-31	Kerr Hollow Gate	0.7
HP-32	Midway Gate	0.9
HP-33	Gallaher Gate	0.7
HP-34	White Oak Dam	0.8
HP-35	Blair Gate	0.7
HP-36	Turnpike Gate	0.6
HP-37	Hickory Creek Bend	0.6
HP-38	E EGCR	0.7
HP-39	Townsite	0.7
Average		0.7

Table 4.1.8 Continuous Air Monitoring Data
Specific Radionuclides in Air
(Composite Samples)
1977
Units of 10^{-15} μCi/cc

Radionuclides	Yearly Average		
	Local Stations	Perimeter Stations	Remote Stations
^{7}Be	136	122	132
^{54}Mn	0.22	$\leq$ 0.22	$\leq$ 0.18
^{57}Co	$\leq$ 0.42	$\leq$ 0.01	ND*
^{60}Co	0.23	$\leq$ 0.11	$\leq$ 0.018
^{90}Sr	1.6	1.3	1.7
^{95}Zr	20	17	21
^{95}Nb	40	36	43
^{103}Ru	13	12	14
^{106}Ru	13	11	12
^{125}Sb	13	1.1	1.3
^{137}Cs	5.0	1.6	1.6
^{141}Ce	10	10	12.4
^{144}Ce	22	21	22
^{228}Th	0.040	0.024	0.015
^{230}Th	0.030	0.021	0.013
^{232}Th	0.040	0.022	0.013
^{234}U	0.45	0.51	0.061
^{235}U	0.036	0.037	0.020
^{238}U	0.23	0.48	0.037
^{238}Pu	0.090	0.0014	0.0011
^{239}Pu	0.031	0.016	0.19

* Not detectable.

Table 4.1.9 Concentration of ^{131}I in Raw Milk - 1977

Station Number	Number Samples/Yr	Qtr. Avg. - Units of 10^{-9} μCi/ml				Weekly Concentrations			Comparison with Standard[b]
		1	2	3	4	Min.[a]	Max.	Avg.	
Immediate Environs[c]									
1	50	< 0.45	< 0.45	1.4	1.0	< 0.45	7.2	< 0.8	1
2	50	< 0.45	< 0.45	2.1	1.4	< 0.45	19.	< 1.1	1
3	50	< 0.45	< 0.45	2.1	2.3	< 0.45	14.	< 1.3	1
4	47	< 0.45	< 0.45	2.3	2.2	< 0.45	16.	< 1.4	1
5	47	< 0.45	< 0.45	6.7	7.3	< 0.45	75.	< 3.3	1
6	45	0.66	< 0.45	5.1	5.7	< 0.45	35.	< 3.0	1
7	50	< 0.45	< 0.45	6.5	3.8	< 0.45	46.	< 2.8	1
8	48	< 0.45	< 0.45	3.8	1.7	< 0.45	23.	< 1.6	1
Average								< 1.9	1
Remote Environs[d]									
51	8	< 0.45	< 0.45	< 2.9	< 0.45	< 0.45	7.9	< 1.4	1
52	9	< 1.1	< 0.45	< 2.2	< 0.45	< 0.45	4.3	< 1.2	1
53	11	< 0.45	< 0.45	< 0.9	< 1.2	< 0.45	1.7	< 0.8	1
54	9	< 0.45	< 0.45	< 0.45	3.2	< 0.45	4.1	< 1.1	1
55	9	< 0.45	< 0.7	< 0.45	3.3	< 0.45	5.6	< 1.2	1
Average								< 1.1	1

a Minimum detectable concentration of ^{131}I is 0.45×10^{-9} μCi/ml.
b Applicable FRC standard, assuming 1 liter per day intake: No. 1 = Range I 0 to 1×10^{-8} μCi/ml - Adequate surveillance required to confirm calculated intakes.
c See Fig. 4.0.6, page 31.
d See Fig. 4.0.7, page 32.

Table 4.1.10 Concentration of ^{90}Sr in Raw Milk - 1977

Station Number	Number Samples/Yr	Qtr. Avg. - Units of 10^{-9} μCi/ml 1	2	3	4	Weekly Concentrations Min.[a]	Max.	Avg.	Comparison with Standard[b]
				Immediate Environs[c]					
1	51	2.6	2.7	3.8	3.0	1.6	8.2	3.0	1
2	51	1.9	2.5	2.8	2.4	0.9	5.0	2.4	1
3	50	2.9	2.3	2.8	3.5	1.6	4.6	2.9	1
4	48	3.0	3.0	3.5	3.1	1.4	7.7	3.2	1
5	47	3.1	3.0	3.9	3.6	1.8	8.0	3.4	1
6	46	3.2	5.0	4.6	4.5	2.3	7.1	4.3	1
7	51	2.4	4.6	5.8	4.0	1.4	10.7	4.2	1
8	49	2.4	3.9	4.0	3.2	0.9	6.8	3.4	1
Average								3.4	1
				Remote Environs[d]					
51	8	2.7	2.8	3.3	2.2	1.6	3.9	2.8	1
52	9	1.1	0.9	1.6	1.8	0.7	2.1	1.4	1
53	11	2.1	4.1	2.7	3.1	1.4	4.8	2.9	1
54	9	1.3	1.6	2.6	2.3	1.1	3.2	1.9	1
55	9	3.5	3.1	4.0	4.2	2.5	4.8	3.6	1
Average								2.5	1

a Minimum detectable concentration of ^{90}Sr is 0.5×10^{-9} μCi/ml.
b Applicable FRC standard, assuming 1 liter per day intake: No. 1 = Range I 0 to 1×10^{-8} μCi/ml - Adequate surveillance required to confirm calculated intakes.
c See Fig. 4.0.6, page 31.
d See Fig. 4.0.7, page 32.

ORNL-DWG. 78-4649

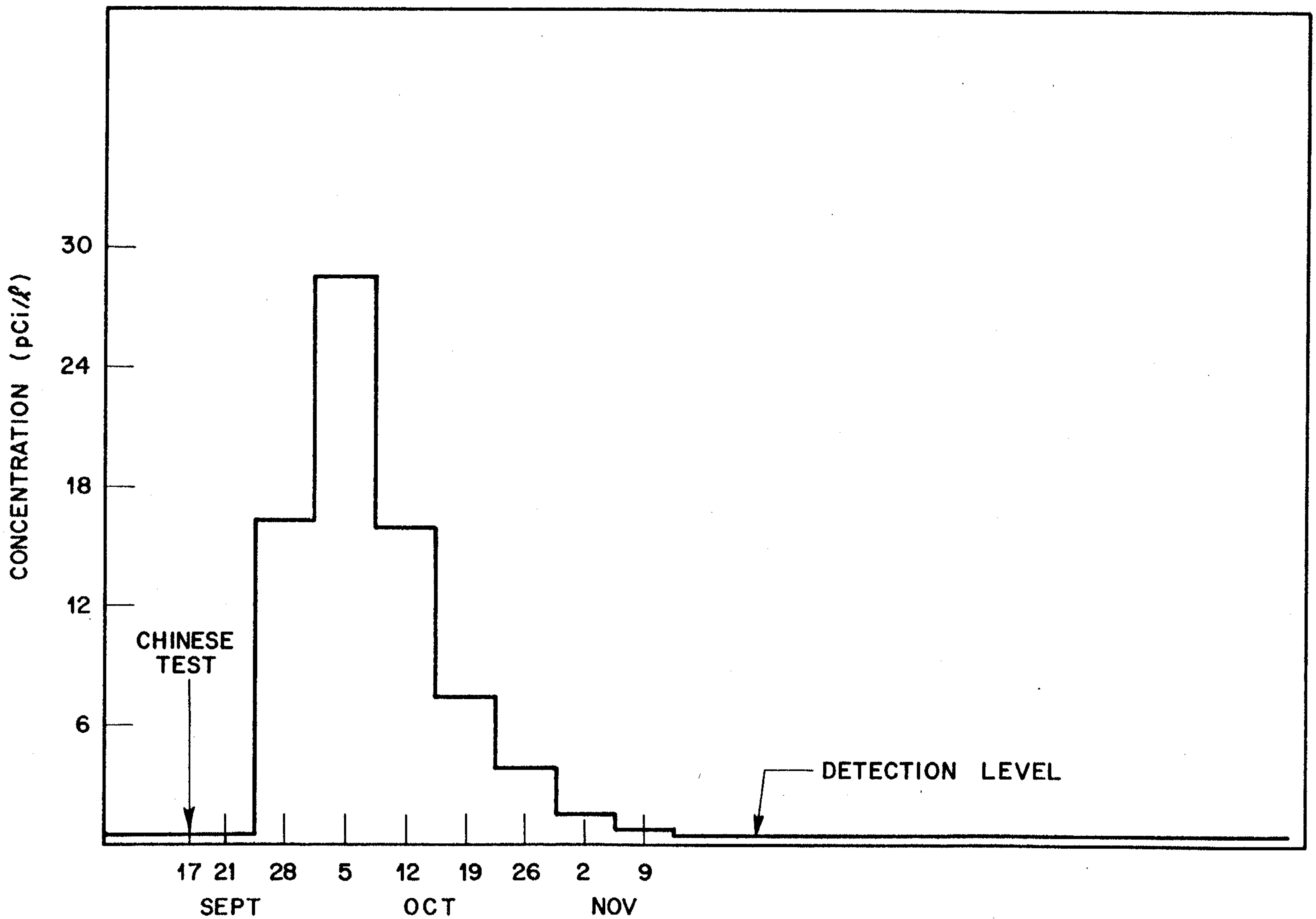


Fig. 4.0.9 Weekly Average of ^{131}I Concentration of the Eight Local Milk Stations Following the Chinese Test, Sept. 17, 1977

Table 4.1.11 Annual Discharges of Radionuclides to the Atmosphere[a]
(Curies)

Stack Number	^{3}H	^{85}Kr	^{131}I	^{133}Xe	Pu[b]	U[b]	Unidentified Alpha
3039	< 2,500	< 6,824	1.19	< 33,330	ND[c]	ND	
7025	< 24	ND	ND	ND	ND	ND	
7911	ND	< 1,782	0.8	< 8,700	ND	ND	
Bldg. 9204-3 Stack (Y-12)					4.0×10^{-6}	1.0×10^{-6}	
Trans Lab							< 1.6 E-8
4509							4.4 E-9
Total	< 2,524	< 8,606	1.37	< 42,030	4.0×10^{-6}	1.0×10^{-6}	< 2.0 E-8

[a]Data furnished by Operations Division.

[b]Mixture of all isotopes.

[c]Not detectable.

Table 4.2.1 Annual Discharges of Radionuclides to the Clinch River (Curies)

Year	^{137}Cs	^{106}Ru	^{90}Sr	^{95}Zr	^{95}Nb	Trans U Alpha	^{3}H
1968	1.1	5.2	2.8	0.27	0.27	0.04	9700
1969	1.4	1.7	3.1	0.18	0.18	0.2	12200
1970	2.0	1.2	3.9	0.02	0.02	0.4	9500
1971	0.93	0.50	3.4	0.01	0.01	0.05	8900
1972	1.7	0.52	6.5	0.01	0.01	0.05	10600
1973	2.3	0.69	6.7	0.05	0.05	0.08	15000
1974	1.2	0.22	6.0	0.02	0.02	0.02	8600
1975	0.62	0.30	7.2	NA*	NA	0.02	11000
1976	0.24	0.16	4.5	NA	NA	0.01	7400
1977	0.21	0.20	2.7	NA	NA	0.03**	6250

4.9
Σ 3.14

*NA - No analysis performed.

**Radionuclides identified from yearly composite sample.

Table 4.2.2 Radionuclides In The Clinch River - 1977

Location	No. of Samples	Range	Concentration of Radionuclides of Primary Concern Units of 10^{-9} μCi/ml				% CG^a
			^{90}Sr	^{137}Cs	^{106}Ru	^{3}H	
C-2 CRM 23.1[b]	4	Max.	0.23	0.0	0.14	636	
		Min.	0.05	0.0	0.09	386	
		Avg.	0.15±0.08[c]	0.0	0.10±0.02	494±104	0.07
CRM 20.8[c]	12	Max.	1.85	0.26	0.15	4401	
		Min.	0.26	0.01	0.01	276	
		Avg.	0.62±0.24	0.05±.04	0.05±0.02	1448±660	0.28
C-3 CRM 14.5[b]	4	Max.	0.36	0.05	0.23	3048	
		Min.	0.05	0.0	0.09	1319	
		Avg.	0.18±0.16	0.03±.02	0.15±0.06	1785±842	0.13
C-5 CRM 4.5[b]	4	Max.	0.41	0.5	0.32	2047	
		Min.	0.05	0.5	0.09	455	
		Avg.	0.27±0.18	0.5	0.19±0.10	1000±730	0.13

[a] Most restrictive concentration guide for each isotope used for calculating percent concentration guide.

[b] Measured values in the Clinch River.

[c] Two standard deviations from the mean.

[d] Values given for this location are calculated values based on the concentrations measured at White Oak Dam (Station W-1) and the dilution afforded by the Clinch River. The yearly average dilution factor was 537.

Table 4.2.3 Calculated Percent MPC_w of ORNL Liquid Radioactivity Releases at White Oak Dam, Intersection of White Oak Creek and Clinch River, and in the Clinch River Water Below the Mouth of White Oak Creek - 1977

Month	WOD	Intersection of WOC & CR	Calculated Value for C. R.*
January	114	33	0.2
February	100	56	0.3
March	89	73	0.9
April	105	34	0.3
May	227	14	0.2
June	111	14	0.3
July	115	10	0.1
August	109	9	0.1
September	103	11	0.3
October	92	16	0.3
November	85	19	0.3
December	95	28	0.1
AVERAGE	112	26	0.3

*Values @ WOD divided by dilution of C. R.

Table 4.2.4 Annual Average Percent MPC_w of Beta Emitters, Other than Tritium, in the Clinch River[a]

Year	CRM 23.1[b]	CRM 20.8[c]	CRM 14.5[b]	CRM 4.5[b]
1968	0.17	0.83	0.37	0.52
1969	0.30	0.36	0.48	0.41
1970	0.22	0.27	0.53	0.47
1971	0.21	0.20	0.65	0.44
1972	0.18	0.26	0.58	0.48
1973	0.24	0.49	0.47	0.62
1974	0.06	0.36	0.26	0.21
1975	0.03	0.43	0.14	0.12
1976	0.05	0.44	0.23	0.15
1977	0.05	0.21	0.07	0.10

[a] Values are predominately from ^{90}Sr.

[b] Values given for this location are based on analyses of water taken directly from the river.

[c] Values given for this location are calculated from the levels of radionuclides released from White Oak Dam and dilution provided by the Clinch River. The contribution from upstream as measured at CRM 23.1 is not included.

Table 4.2.5 Annual Average Percent MPC_w of Tritium in the Clinch River

Year	CRM 20.8[a]
1968	0.07
1969	0.11
1970	0.05
1971	0.04
1972	0.04
1973	0.07
1974	0.04
1975	0.06
1976	0.07
1977	0.05

[a] Values given are calculated from the level of waste released from White Oak Dam and dilution provided by the Clinch River.

Table 4.2.6 Radionuclide Content of Clinch River Fish - 1977
pCi/kg Wet Weight

Location	Species[a]	^{40}K	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs	^{239}Pu	Est. % MPI[b]
CRM 22								
Above White Oak Creek and Below Melton Hill Dam	Crappie	1980	$\leq$ 47	121	180	2038	< 0.024	1.1
	Blue Gill	3760	$\leq$ 39	27	101	670	0.112	0.28
	Carp	2400	$\leq$ 19	133	$\leq$ 19	154	< 0.012	0.95
	Bass	2325	$\leq$ 13	13	$\leq$ 20	360	$\leq$ 0.013	0.13
	Shad	5691	$\leq$ 16	44	$\leq$ 63	49	$\leq$ 0.063	0.33
CRM 20.8								
Mouth of White Oak Creek	Crappie	2141	$\leq$ 39	150	$\leq$ 52	1461	0.007	1.2
	Blue Gill	2062	$\leq$ 72	815	$\leq$ 76	1397	0.086	5.8
	Carp	2309	$\leq$ 20	69	$\leq$ 29	306	< 0.016	0.52
	Bass	2144	$\leq$ 55	330	$\leq$ 105	5397	< 0.093	0.29
	Shad	2002	$\leq$217	43	$\leq$ 127	3187	0.027	0.66
CRM 12								
Below Mouth of Poplar Creek	Bass	878	$\leq$ 10	44	$\leq$ 20	$\leq$ 10	< 0.02	0.31
	Shad	1608	47	145	74	734	0.082	1.1

[a] Composite of 10 fish in each species for CRM 22 and CRM 12; 20 fish in each species for CRM 20.8.

[b] Maximum Permissible Intake - Intake of radionuclide from eating fish is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of radionuclides in question. Consumption of fish is assumed to be 37 lb/yr of the species in question. Only man made radionuclides were used in the calculation.

4.2.7 Trace Element Composition of Clinch River Fish - 1977
(μg/g Wet Weight)

Location	Species[a]	Al	As	Br	Cd	Cl	Co	Cr	Cs	Cu	Fe	Hg	Mn	Se	Sr	Th	U	Zn	Zr
CRM 22.0	Crappie	3.00	≤0.17	2.9	≤0.44	289	0.0045	≤0.10	0.0082	1.74	4.00	0.086	0.45	≤0.087	≤5.22	≤0.0087	0.0087	7.30	≤1.74
	Blue Gill	5.21	≤0.12	2.2	≤0.31	260	0.0072	≤0.062	≤0.0053	1.24	5.75	0.033	0.60	≤0.062	≤4.96	≤0.0062	0.0012	7.19	≤1.24
	Carp	3.66	≤0.14	2.53	≤2.06	514	0.016	≤0.137	0.0069	≤1.37	13.02	0.515	0.75	≤0.0069	≤9.59	≤0.014	0.00096	13.2	≤2.06
	Bass	2.92	≤0.15	2.46	≤0.074	292	0.0033	≤0.074	0.0061	≤1.48	5.08	0.066	0.30	≤0.074	3.70	≤0.0074	≤0.00015	6.96	≤1.48
	Shad	5.60	≤0.53	4.59	≤5.25	581	0.00095	0.20	0.013	≤5.25	20.0	0.022	3.15	≤0.18	NA	≤0.018	0.0014	27.0	≤3.50
CRM 20.8	Crappie	4.09	≤0.16	2.62	≤1.69	290	≤0.010	≤0.16	0.011	≤1.56	3.08	0.044	0.69	≤0.12	≤7.65	≤0.012	0.00089	6.11	≤2.34
	Blue Gill	2.26	≤0.11	1.96	≤0.28	267	0.0054	≤0.069	≤0.020	≤1.24	3.35	0.187	0.85	≤0.068	≤5.38	≤0.0068	0.00065	8.69	≤1.35
	Carp	2.51	≤0.30	1.99	≤1.18	395	0.011	≤0.13	≤0.0044	≤1.10	8.38	0.233	0.63	≤0.072	≤8.53	≤0.016	0.0075	11.80	≤2.13
	Bass	3.11	≤0.11	2.72	≤1.84	254	0.0034	≤0.093	≤0.0083	≤1.88	2.86	0.33	≤0.48	≤0.068	≤8.05	≤0.0093	≤0.00026	5.35	≤1.52
	Shad	4.43	≤0.20	4.29	≤1.39	515	0.018	0.065	≤0.0060	≤2.31	11.1	0.042	3.04	≤0.075	≤5.52	≤0.0075	0.0067	5.62	≤1.50
CRM 12.0	Bass	2.82	≤0.018	2.33	≤1.11	351	0.013	≤0.056	0.0073	≤5.49	6.66	0.156	2.55	≤0.055	NA	≤0.0055	0.034	4.08	≤1.11
	Shad	4.74	≤0.22	4.30	≤3.66	544	0.018	≤0.092	0.0055	≤3.66	6.92	0.156	3.66	≤0.033	NA	≤0.0092	0.012	6.31	≤1.83

a Composite of 10 fish in each species for CRM 22 and CRM 12; 20 fish in each species for CRM 20.8.

Table 4.3.1 External Gamma Radiation Measurements at Local Air Monitoring Stations - 1977

Station Number	μR/hr	mR/yr[a] ± %[b]
HP-1	89	781 ± 18
HP-2	91	797 ± 5
HP-3	10	88 ± 9
HP-4	188	1647 ± 13
HP-5	44	385 ± 7
HP-6	57	500 ± 29
HP-7	9	79 ± 7
HP-8	10	88 ± 13
HP-9	10	88 ± 7
HP-10	16	140 ± 13
HP-11	13	114 ± 26
HP-12	52	456 ± 10
HP-13	222	1945 ± 11
HP-14	16	140 ± 9
HP-15	23[d]	201
HP-16	11	96 ± 8
HP-17	15	131 ± 26
HP-18	15[d]	131
HP-19	16	140 ± 13
HP-20	14	123 ± 15
HP-21	8	70 ± 20
HP-22	17	149 ± 22
HP-23	12	105 ± 54
Average	42	365 ± 137

[a] Calculated assuming that an individual remained at this point for 24 hours/day for the entire year.

[b] Percentage coefficient of variation (standard deviation/arithmetic mean).

[c] Average of two samples.

d One sample.

Table 4.3.2 External Gamma Radiation Measurements - 1977

Station Number	Location	Number of Measurements Taken	Readings μR/hr	Readings mR/yr
Perimeter Stations[a]				
HP-31	Kerr Hollow Gate	12	8.5 ± 1.1[b]	74 ± 10
HP-32	Midway Gate	12	10.8 ± 1.0	95 ± 9
HP-33	Gallaher Gate	12	7.9 ± 0.7	69 ± 6
HP-34	White Oak Dam	12	12.3 ± 0.8	108 ± 7
HP-35	Blair Gate	12	7.3 ± 0.7	64 ± 6
HP-36	Turnpike Gate	12	7.5 ± 0.8	66 ± 7
HP-37	Hickory Creek Bend	12	7.5 ± 0.7	66 ± 6
HP-38	East of EGCR	12	7.6 ± 0.7	67 ± 6
HP-39	Townsite	12	7.9 ± 0.7	69 ± 6
HP-40	Melton Hill	12	6.1 ± 0.6	53 ± 5
Average			8.3 ± 0.3	73 ± 2
Remote Stations[c]				
HP-51	Norris Dam	2	6.7 ± 0.1	59 ± 1
HP-52	Loudoun Dam	2	7.8 ± 0.3	68 ± 3
HP-53	Douglas Dam	2	8.1 ± 1.5	71 ± 13
HP-54	Cherokee Dam	2	7.6 ± 1.6	67 ± 14
HP-55	Watts Bar Dam	2	6.8 ± 0.5	60 ± 4
HP-56	Great Falls Dam	2	7.5 ± 3.7	66 ± 32
HP-57	Dale Hollow Dam	2	8.5 ± 1.5	74 ± 13
HP-58	Knoxville	2	10.8 ± 0.5	95 ± 4
Average			8.0 ± 0.6	70 ± 5

[a] See Fig. 4.0.3, page 28.

[b] Two standard deviations from the mean.

[c] See Fig. 4.0.4, page 29.

Table 4.3.3 External Gamma Radiation Measurements Along the Perimeter of the DOE - Oak Ridge Controlled Area - 1977

Location[a]	μR/hr	mR/yr[b] ± %[c]
HP-41	13.8	121 ± 12
HP-42	20.7	181 ± 10
HP-60	13.3	117 ± 33
HP-61	21.2	186 ± 42
HP-62	39.5	346 ± 56
HP-63	49.1	430 ± 29
HP-64	29.4	258 ± 26
HP-65	34.4	301 ± 14
HP-66	37.4	328 ± 15
HP-67	19.4	170 ± 26
HP-68	11.95	105 ± 18
HP-69	10.8	95 ± 23

[a] See Fig. 4.0.8, ORNL-76-12776, page 33.

[b] Calculated assuming that an individual remained at this point for the entire year.

[c] Percentage coefficient of variation.

Table 4.4.1 Radioisotope Concentrations in Soil - 1977
(Units of pCi/g - Dry)[a]

Sampling Location[b]	^{40}K	^{90}Sr	^{137}Cs	^{226}Ra	^{234}U	^{235}U	^{238}U	^{238}Pu	^{239}Pu
Perimeter									
HP-23	NA*	0.54	0.8	0.9	0.61	0.032	0.67	< 0.00045	0.014
HP-31	12.0	0.59	1.5	1.0	0.46	0.030	0.30	0.0020	0.018
HP-32	34.0	0.29	1.8	1.2	2.4	0.090	0.92	0.0014	0.025
HP-33	13.2	0.95	3.0	1.8	0.46	0.025	0.30	0.0050	0.044
HP-34	18.1	0.59	1.6	1.1	0.33	0.021	0.26	0.0090	0.023
HP-35	6.4	0.72	1.8	1.7	0.52	0.063	0.41	0.0014	0.027
HP-36	10.3	0.54	1.7	1.3	0.39	0.032	0.31	0.00090	0.028
HP-37	11.9	0.23	1.3	1.1	0.28	0.017	0.21	0.0032	0.014
HP-38	13.9	1.62	1.5	1.3	0.44	0.037	0.21	< 0.00045	0.015
HP-39	18.1	0.72	1.8	1.2	0.98	0.072	0.95	0.0041	0.013
Average	15.3	0.68	1.7	1.3	0.69	0.042	0.45	0.0028	0.022
Remote									
HP-51	9.6	0.38	2.1	1.5	0.25	0.015	0.19	0.0014	0.018
HP-52	17.4	0.59	1.3	1.5	0.55	0.030	0.47	0.0041	0.018
HP-53	NA	0.42	1.5	1.7	0.63	0.025	0.54	0.0018	0.018
HP-54	24.6	0.43	1.3	1.0	0.49	0.022	0.33	0.0045	0.0095
HP-55	7.4	0.63	1.4	1.6	0.44	0.050	0.39	0.0027	0.018
HP-56	5.8	0.37	1.7	1.2	0.25	0.015	0.23	0.0023	0.016
HP-57	20.0	0.23	1.3	1.2	0.41	0.018	0.36	0.0036	0.017
HP-58	19.6	0.31	1.4	1.4	0.36	0.016	0.31	0.00090	0.019
Average	14.9	0.42	1.5	1.4	0.43	0.024	0.35	0.0027	0.017

[a] Applicable guides for soil contamination have not been established. Each value listed is from nine samples collected in a one-square-meter area at each location and composited for analysis.

[b] See Fig. 4.0.3, page 28 and Fig. 4.0.4, page 29.

* Not analyzed.

Table 4.4.2 Radioisotope Concentrations in Grass Samples - 1977
(Units of pCi/g - Dry)

Sampling Location[a]	^{7}Be	^{90}Sr	^{95}Nb	^{95}Zr	^{103}Ru	^{137}Cs	^{140}La	^{141}Ce	^{144}Ce	^{234}U	^{235}U	^{238}U	^{239}Pu
						Perimeter							
HP-23	17.1	5.3	9.5	4.4	2.8	0.44	8.9	8.1	6.9	0.40	0.013	0.82	0.0081
HP-31	20.4	3.3	12.6	6.4	4.3	0.65	11.0	10.8	7.3	0.21	0.0068	0.15	0.0077
HP-32	19.8	2.7	11.3	5.2	3.4	0.75	10.1	9.3	7.1	0.62	0.011	0.35	0.014
HP-33	11.7	3.1	11.5	5.8	2.5	0.40	6.7	7.8	5.3	0.14	0.0032	0.081	0.0072
HP-34	141	1.8	32.1	11.1	5.0	1.3	ND*	17.2	22.2	0.09	0.0027	0.030	0.0081
HP-35	21.6	3.1	14.9	6.7	3.7	1.3	12.7	11.9	9.7	0.50	0.013	0.26	0.021
HP-36	14.5	2.8	9.5	4.8	2.6	0.51	6.7	7.9	5.6	0.29	0.014	0.18	0.012
HP-37	89.2	2.7	24.1	7.8	3.9	0.75	ND	12.3	16.6	0.030	0.0018	0.028	0.0054
HP-38	107	1.6	21.4	7.6	3.5	1.1	ND	11.0	19.9	0.044	0.0023	0.026	0.0050
HP-39	19.5	3.4	13.9	7.0	4.2	0.35	ND	10.2	7.7	0.22	0.0090	0.17	0.0090
Average	46.2	3.0	16.1	6.7	3.6	0.76	< 9.4	10.7	10.8	0.25	0.0077	0.21	0.0098
						Remote							
HP-51	17.2	2.9	9.9	3.3	2.8	0.30	ND	9.9	6.3	0.037	0.0036	0.021	0.0036
HP-52	17.4	3.5	13.1	6.4	4.3	ND	11.8	10.5	7.2	0.086	0.0045	0.054	0.0081
HP-53	11.1	1.8	6.8	4.1	2.2	0.24	ND	6.2	5.6	0.32	0.013	0.34	0.0032
HP-54	10.5	2.3	4.3	3.0	1.6	ND	ND	4.1	4.3	0.15	0.0054	0.13	0.0023
HP-55	8.0	2.3	6.3	2.0	2.0	0.19	ND	6.3	3.7	0.086	0.0059	0.099	0.0054
HP-56	49.8	4.4	40.1	17.0	9.7	0.97	39.7	25.9	21.9	0.095	0.0023	0.063	0.0077
HP-57	8.0	1.3	3.2	1.6	0.8	0.29	ND	2.4	4.1	0.077	0.0041	0.059	0.0054
HP-58	8.5	0.7	2.3	1.7	0.6	0.58	ND	7.1	3.4	0.30	0.013	0.28	0.017
Average	16.3	2.4	10.8	4.9	3.0	< 0.43	< 25.8	9.1	7.1	0.48	0.0055	0.13	0.0066

[a] See Fig. 4.0.3, page 28 and Fig. 4.0.4, page 29.
* Not detectable.

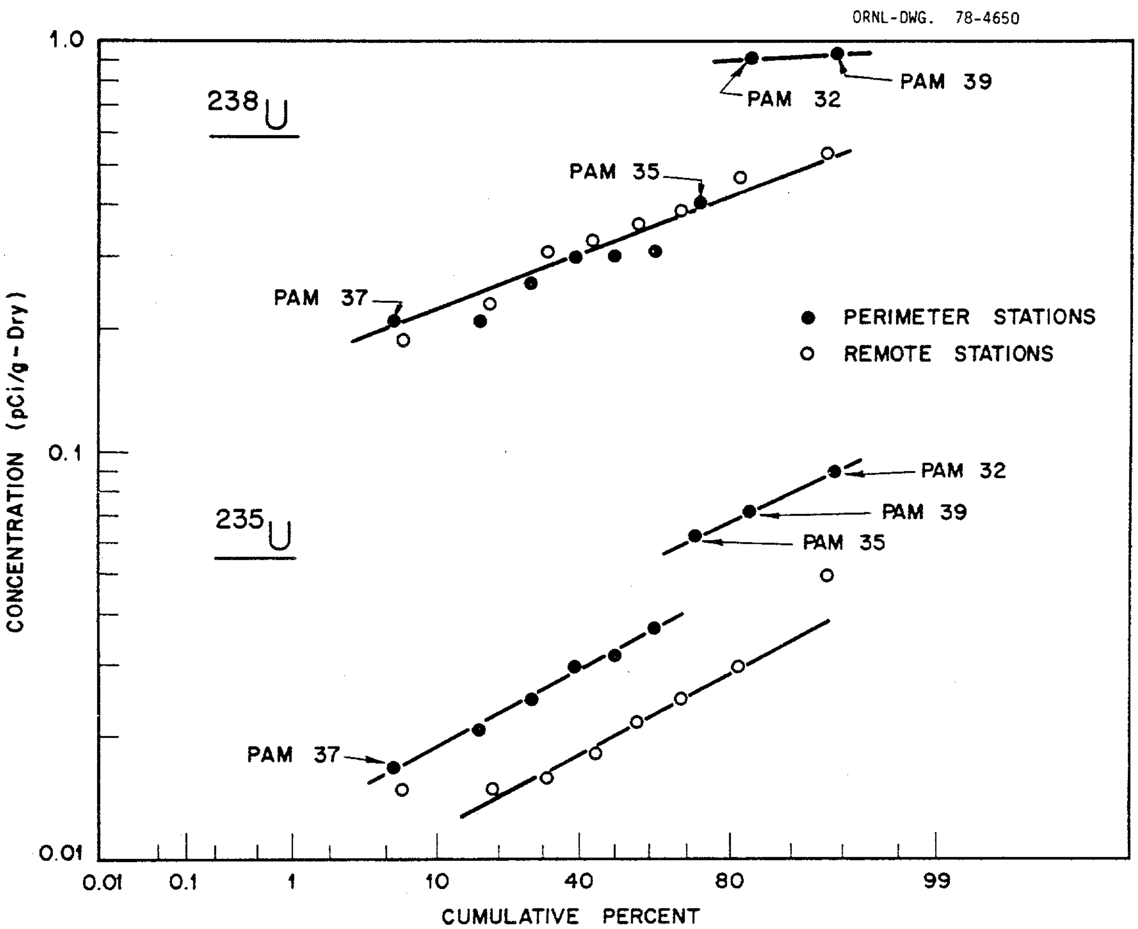


Fig. 4.0.10 Distribution Plot of Uranium in Soil from Perimeter and Remote Stations

ORNL-DWG. 78-4651

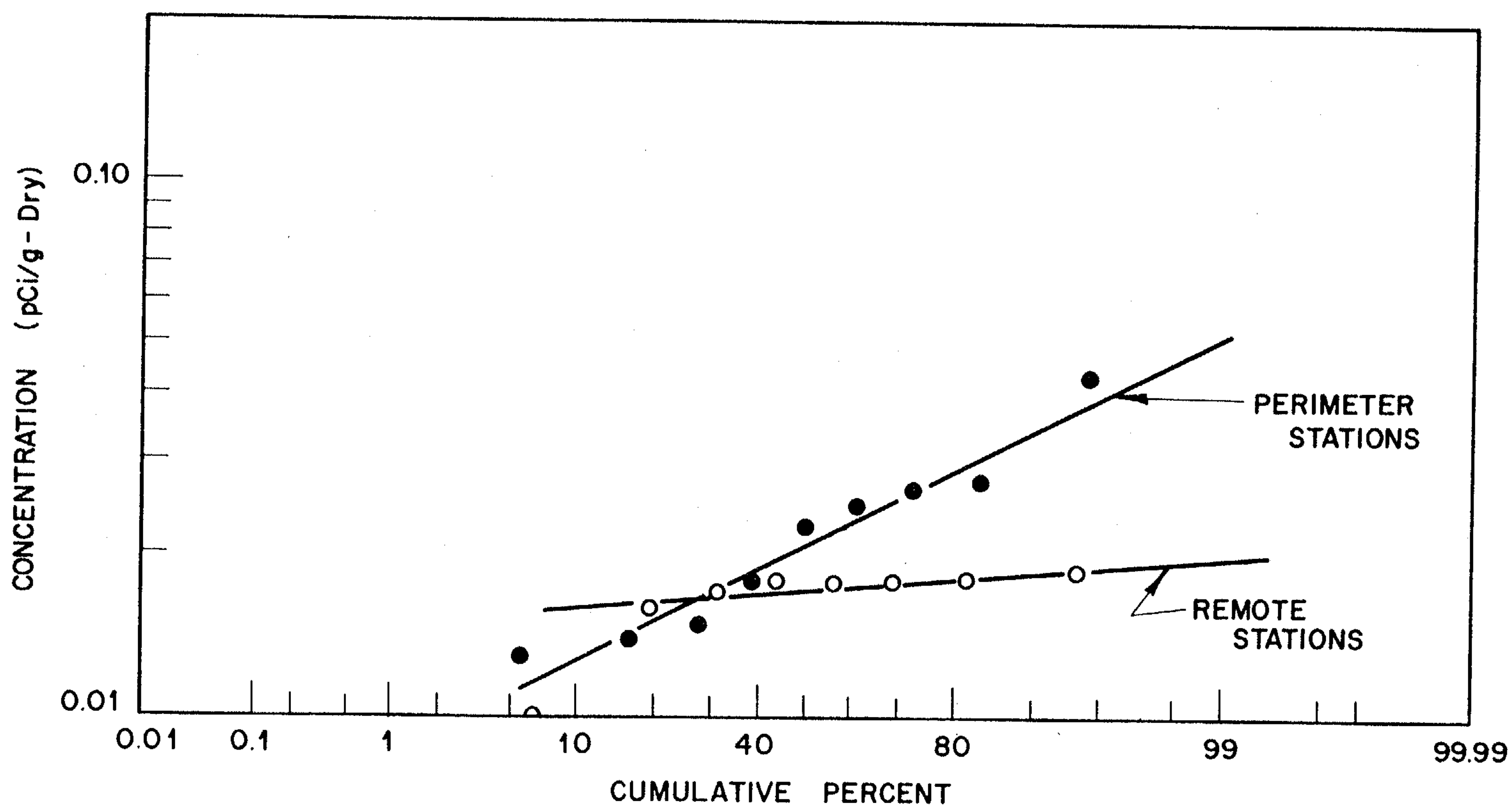


Fig. 4.0.11 Distribution Plot of ^{239}Pu in Soil from Perimeter and Remote Stations

Table 4.5.1 Radionuclide Concentrations in Deer Muscle Samples - 1977
(pCi/kg Wet)

Sample Number	Location	On Oak Ridge Reservation	^{40}K	^{137}Cs	^{134}Cs	^{60}Co	^{65}Zn
D-1	Chestnut Ridge Park	No	4.14	0.416	ND*	∿ 0.026	∿ 0.078
D-2	Norris Lake	No	3.80	0.136	ND	ND	ND
D-3	K-25 Area	Yes	4.12	0.052	ND	ND	ND
D-4	White Oak Creek	Yes	4.55	2.26×10^3	10.4	Trace	Trace
D-5	Burial Ground No. 5	Yes	4.18	6.73	ND	0.080	0.586
D-6	Junction of Highway 95 and Bear Creek Road	Yes	4.87	2.25	ND	ND	ND
D-7	One-Half Mile East of 7000 Area, X-10	Yes	4.48	0.292	ND	ND	ND
D-8	Highway 95, One Mile East of 95/58	Yes	4.50	0.537	ND	ND	ND

* Not detectable.

Table 4.6.1 Environmental Monitoring Samples - 1977

Sample Type	Type of Analyses	Number of Samples
Monitoring Network Air Filters	Gross Alpha, Gross Beta	1664
Monitoring Network Air Filters	Autoradiogram	1248
Monitoring Network Air Filters	Gamma Spectrometry, Wet-Chemistry	12 Groups
Gummed Paper Fallout Trays	Autoradiogram	1248
Gummed Paper Fallout Trays	Long-Lived Activity Count	1664
Charcoal Cartridge	^{131}I	1248
Fish	Radiochemical, Gamma Spectrometry	10 Groups
Rainwater	Gross Beta	938
Raw Milk	^{131}I, ^{90}Sr	468
White Oak Dam Effluent	Gross Beta, Radiochemical, Gamma Spectrometry	408
White Oak Creek	Gross Beta, Radiochemical, Gamma Spectrometry	236
Clinch River Water	Radiochemical, Gamma Spectrometry	54
Potable Water	Radiochemical, Gamma Spectrometry	20
Soil Samples	Gamma Spectrometry, Wet-Chemistry	20
Grass Samples	Gamma Spectrometry, Wet-Chemistry	20

ORNL-DWG 77-18790

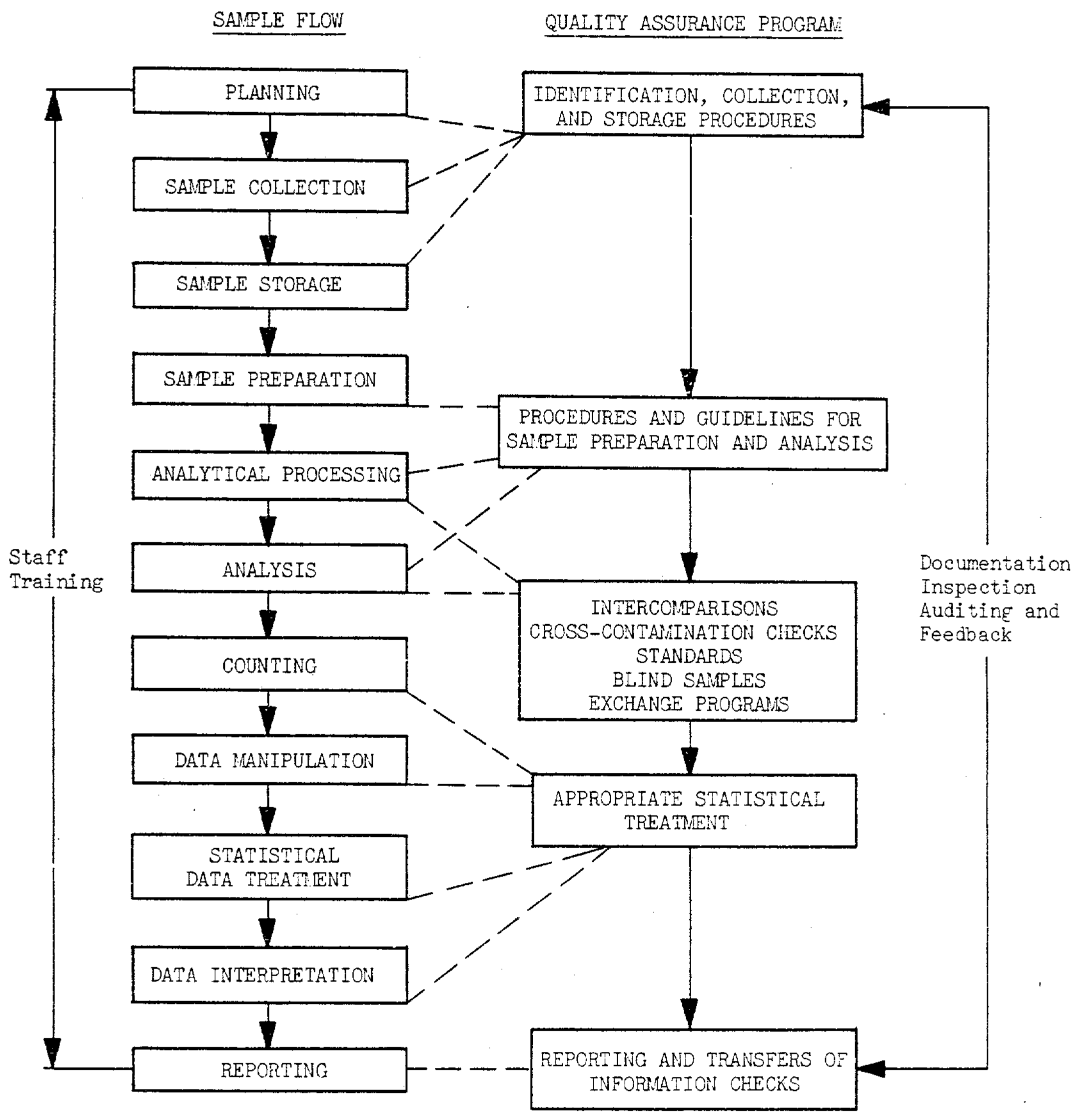


Fig. 1. Flow chart of Q.A. Program

ORNL-DWG 77-19158

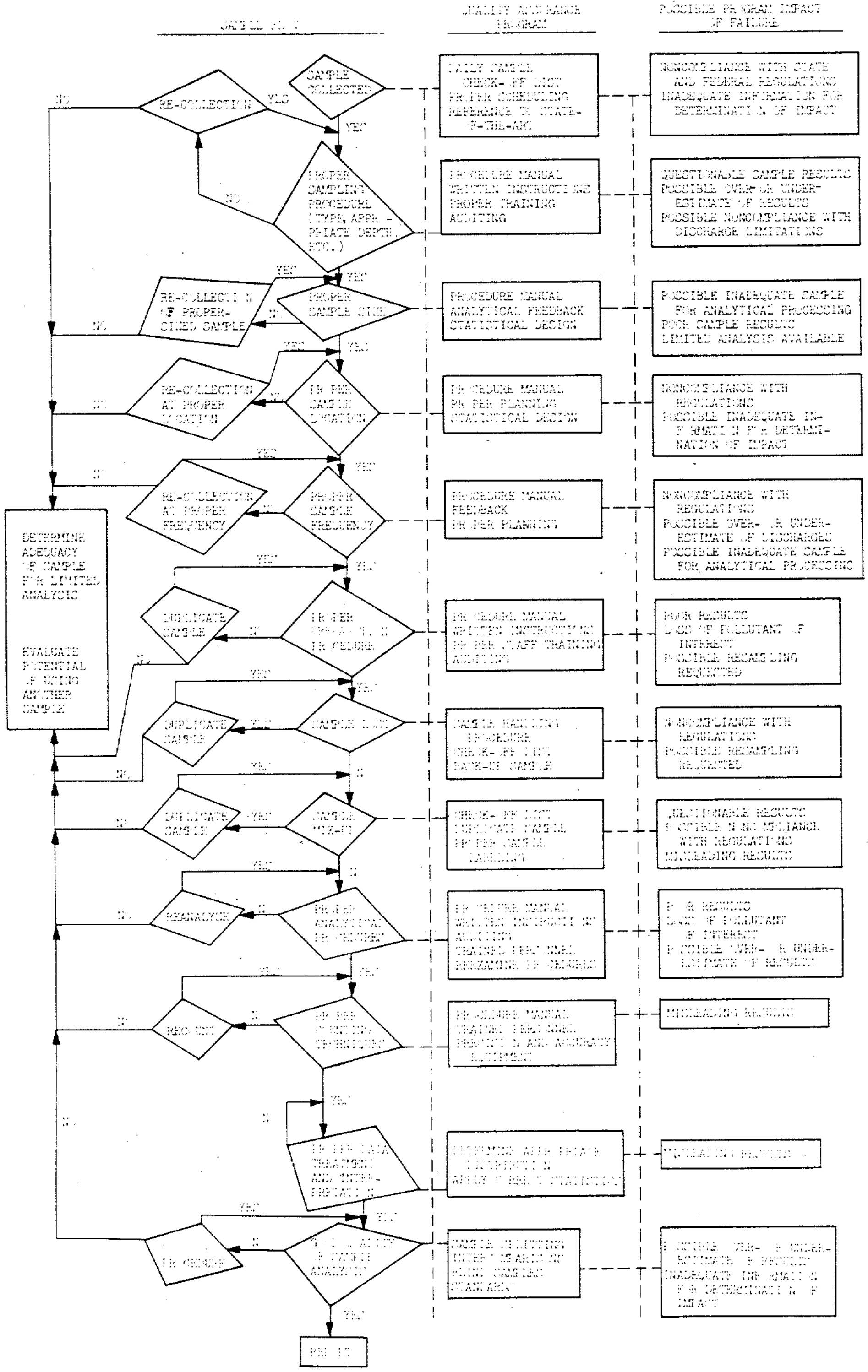


Fig. 2. Interrelationships among sample flow, QA program, and the impact of failure

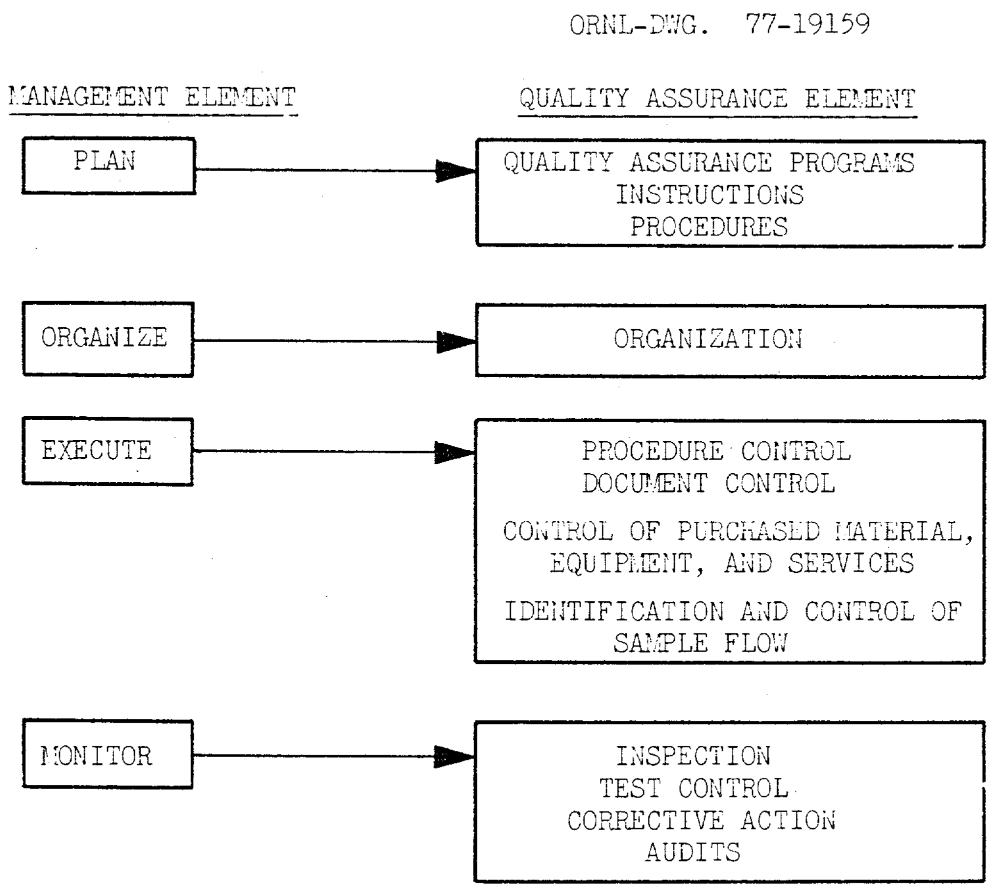


Fig. 3. Management and quality assurance

ORNL-DWG 77-18791

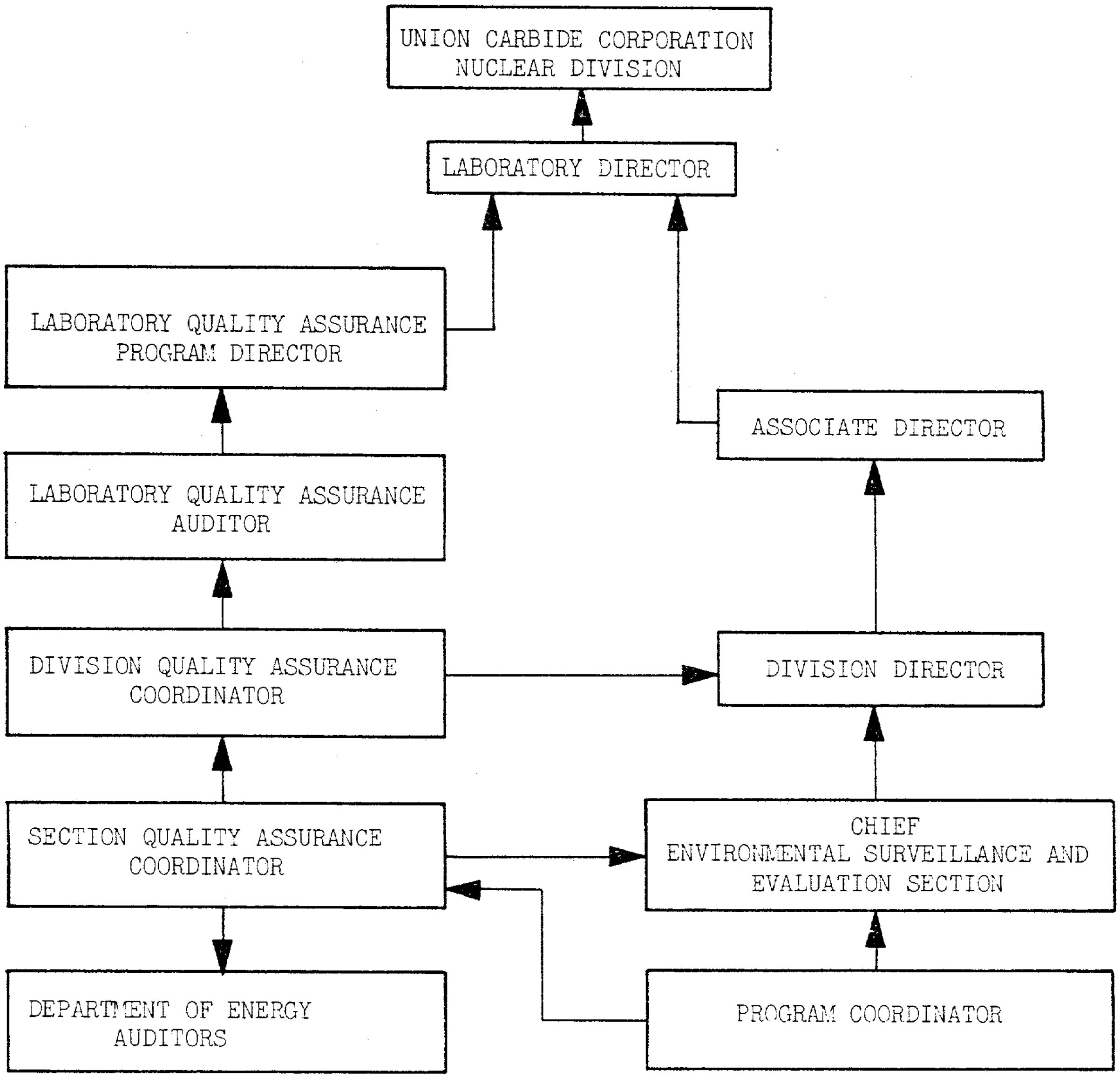


Fig. 4. Quality assurance program organization chart

5.0 RADIATION AND SAFETY SURVEYS

5.1 Laboratory Operations Monitoring

During 1977, Radiation and Safety Surveys personnel assisted the operating groups in keeping the levels of personnel exposure, concentrations of airborne radioactivity, and surface contamination well within established limits. Assistance in reducing or eliminating a number of problems associated with radiation protection was rendered through seminars, safety meetings, and discussions with those supervising and performing radiation work. Following is a brief review of some of the more salient events in which they were involved.

5.1.1 Radiochemical Pilot Plant Operations, Building 3019

In addition to the more routine surveillance activities, Radiation and Safety Survey personnel assisted in the planning of and provided monitoring for 211 jobs or operations where the potential hazards necessitated the execution of Radiation Work Permits. Some of the more significant ones are described below:

a. Maintenance, modifications, and clean-out of the Pilot Plant Solvent Extraction and Ion Exchange ^{233}U purification systems required numerous entries into Building 3019 Cells 5, 6, 7, and the Pipe Tunnel, all of which are highly contaminated with alpha emitters.

b. Building 3019, Pilot Plant Cell #4 was readied for installation of storage wells to contain the uranium from the TRUST Facility after it is solidified and encapsulated. In order to enable construction of this facility with a minimum of protective apparel, the exterior and interior of grossly ^{238}Pu contaminated cubicles were partially decontaminated and the residual contamination bonded by paint or concrete. Extraordinary precautions were necessary to prevent contamination of personnel while working in the cubicles and during unsuiting procedures. Many entries were required by personnel wearing plastic, air-supplied suits over full face masks and a double suiting of coveralls, rubber gloves, shoe covers, and hoods.

5.1.2 Analytical Chemistry Operations, Building 3019

Clean out of HRLAF Cell #1 was initiated. This involved the removal of a sample dissolution hood on top of the cell work tray and numerous pieces of lead and miscellaneous debris from underneath the tray. After extensive remote decontamination using the cell manipulators, gross levels of fission product contamination remained on surfaces underneath the cell tray and radiation fields > 100 rad/hr were encountered. Installation of temporary shielding enabled removal of equipment on top of the cell tray. Extended reach devices were used at the back of the cell to effect further decontamination under the tray and to transfer highly contaminated pieces of lead onto the tray where they will be decontaminated using the cell manipulators. Additional decontamination of cell surfaces will be necessary before personnel can enter the cell with reasonable working times.

Radiation and Safety Surveys personnel participated in a number of quarterly safety inspections scheduled by the operating Divisions. In addition to unsafe conditions or practices noted on these scheduled inspections, over 230 safety items were reported by survey personnel as a result of their day to day safety awareness.

5.1.3 Hot Cell Operations, Buildings 3026-D and 3525

The work of the Hot Cell Operations Group at the High Level Segmenting Cell Facility and the High Radiation Level Examination Laboratory is primarily involved with samples or experiments which are intensely radioactive by virtue of having been irradiated in various reactors around the country. The demand for these services can be illustrated by the fact that over 500 shipments (in and out) of shielded carriers in varying sizes were handled during the year. Additionally, over 30 loads of waste material were generated and transferred to the Solid Waste Facility for disposition. Each of these operations required careful monitoring by Radiation and Safety Surveys personnel in order to assure that radiation shielding and contamination containment provisions conform to Laboratory standards. Personnel exposures were well below permissible levels, and contamination problems were confined to zoned areas where controls were adequate.

5.1.4 Isotope Area Operations, Building 3038 et. al.

Work by the Isotope Research Materials Laboratory, largely the preparation of sources and fissile foils for use by others, continued to expand during the year. Most of their efforts involve isotopes of high hazard index in cells or gloved boxes, but requiring careful surveillance in handling outside of containment enclosures. In one program, 44 grams of ^{241}Am oxide were reduced, melted, and cast for machining. The handling of such materials required the issuance and certification of over 200 Radiation Work Permits.

Additionally, the demand for radioisotopes in medical research and therapy and various industrial uses continued to grow. A total of 3,117 packages of radioactive materials were monitored for shipment from the Laboratory during the year. Dose equivalents for all personnel engaged in this work were well within permissible limits.

5.1.5 Metal Rolling Operations, Building 3550

. A production-scale operation which was undertaken in Laboratory 30 required a significant contribution in the form of surveillance, consultation, and recommendations from Radiation and Safety Surveys personnel. The work consisted of etching, rolling, and annealing of 44 kg of enriched uranium metal. The laboratory committed to this program was not suitably equipped to provide containment for such operations, and the initial surveillance results conclusively indicated that changes were necessary. Modifications to both equipment and procedures were instituted on the basis of health physics findings and recommendations. The work was then completed without undue exposure of personnel or contamination of the facility.

5.1.6 Transuranium Research Laboratory (TRU), Building 5505

TRL Health Physics and Safety personnel continued to provide radiological protection, industrial safety, and technological assistance to individual staff researchers, TRL management, and engineering and craft support personnel to ensure that all building activities were carried out in accordance with a high standard of safety. Activities included: (1) assistance in the planning and design of individual experiments, (2) operational responsibility for building containment facilities, including hoods, glove boxes, and other enclosures, and the air supply, exhaust, and filtration systems, (3) development and documentation of necessary operational procedures in regard to personnel, facility, and environmental safety, (4) organization and implementation of appropriate safety training programs for orientation of new personnel and the continuing in-house safety training of TRL staff, (5) special decontamination of reusable valuable research equipment, and (6) routine and special disposal of hazardous wastes generated in the TRL.

5.1.7 Radiography of Welds, Building 6000

Radiation and Safety Surveys personnel provided surveillance during the radiography of welds made by the Chicago Bridge and Iron Company while fabricating the Holifield Heavy Ion Laboratory Tandem Van de Graaff pressure vessel. A large portion of the work (which employed a 200 Ci ^{192}Ir source) took place in the area between Building 6000 and Bethel Valley Road. During periods when the source was unshielded, elevated levels of gamma radiation were detected there. Consequently, all radiography work requiring use of the source was done after regular work hours. Gamma monitors equipped with audible alarms were placed in areas of Building 6000 which might be affected by the source. Integrating dosimeters placed in the building and along the roadway indicated insignificant exposures to personnel who might have been near the perimeter of the zoned area while the source was in the exposed position.

5.1.8 Nuclear Safety Pilot Plant, Building 7500

Operations in the Nuclear Safety Pilot Plant were resumed during 1977. Following extensive decontamination and modifications to the equipment in Cell B, a series of experiments were performed in which 1.8 kg of depleted uranium and 21 kg of sodium were burned and the combustion products transferred into a Model Containment Vessel for sampling and decontamination procedures. Safety and contamination control procedures applicable to this program were successful in keeping all hazardous materials confined to the cell.

5.1.9 DOSAR Facility, Buildings 7709, 7710

Surveillance and technological assistance were provided by Radiation and Safety Surveys personnel for a variety of research programs at this facility. Among these were the intercomparison of radiation dosimeters (a program with international involvement), a developmental program for a nuclear-pumped laser, and the exposure of animals and other biological specimens at the reactor facility.

5.1.10 Shale Fracturing Facility, Building 7852

Continuous surveillance was provided in November during the injection of approximately 54,000 gallons of liquid waste containing about 16,452 curies of activity. All personnel exposures were kept below maximum permissible levels, and personnel contamination control was adequate.

5.1.11 High Flux Isotope Reactor, Building 7900

The installation of four new beam facilities for fundamental research on atomic nuclei required consultation and surveillance services by personnel of the Radiation and Safety Surveys Section. Shielding and work-area zoning requirements were stipulated for proper protection of research and operating personnel.

In addition, day-to-day support of reactor operations was provided through hazard surveillance during reactor shutdown activities, maintenance work on reactor components, target rod transfers, and various experiments associated with the reactor.

5.1.12 Transuranium Processing Activities, Building 7920

Radiation and Safety Surveys personnel participated extensively in the detailed planning and cautious execution of the procedures necessary to remove and replace the leaky liner from one of the shielded caves which had been used in product finishing operations. The equipment was grossly contaminated with transplutonium nuclides and presented a great potential for release of activity. The control procedures applied succeeded in preventing any significant release outside the immediate work area.

Maintenance operations on equipment in cell pits was also necessary during this period. This work, too, involved high level radiation and contamination problems requiring diligent surveillance attention throughout. These operations were essential for the installation of the IODOX process to enhance the removal of iodine from the product stream.

5.1.13 Fuel Assay Development, Building 7930

A new facility to develop non-destructive assay procedures for nuclear fuel components was installed in Cell B. The program involves the use of Californium-252 and Antimony-Beryllium ($\sim$ 800 curies) as neutron sources to determine the fissile material content of reactor fuel elements. Radiation and Safety Surveys personnel provided the surveillance services necessary for the installation of source materials and the cell access limitations as the work progressed.

5.1.14 Impurity Study Experiment, Building 9201-2

An experimental program to study the sources and behavior of impurities in magnetically confined plasmas was begun in August. The major equipment involved is a toroidally shaped vacuum vessel, one of a class of Tokamaks, surrounded by a 40'x 40'x 24' high safety enclosure of concrete blocks.

The machine is operated in a pulsed mode, with 100 msec pulses at 3 to 5 minute intervals. X-rays are generated when energetic electrons escape the plasma and interact with the torus walls. The radiation levels vary with experimental parameters: rates just outside the safety enclosure usually exceed 20 R/hr, but integrated exposure measurements outside the safety enclosure showed 24 hour totals in the range up to 20 mR in occupied areas.

5.1.15 Contaminated Loop Removals, Building 9204-1

Two grossly contaminated piping systems were disassembled and removed from the building to make way for installation of new equipment. The old thorium slurry loop included a tank which still contained several hundred pounds of thorium. The old HRE mock-up loop was internally contaminated with uranium. Contamination confinement was provided by enclosing the area in a plastic housing and by spray painting. Piping was sawed and ends sealed for removal. The precautions used were successful in keeping the contamination within the zoned area and air-borne concentrations within MPC levels.

5.1.16 Californium Source Installation, Building 9983-17

A 5 mg ($\sim 1.3 \times 10^{10}$ n/sec) of Californium-252 was installed in a trailer structure in a remote section of the Y-12 Area where some small animal experiments are to be performed by the Biology Division. Limited vehicular accessibility to the trailer site necessitated that both an intermediate transfer between shielding carriers and placement of the source into the shielded tube assembly in the trailer be done with rudimentary tools with the source unshielded ($\sim$ 6 rem/hr at 6') for short time intervals. Careful planning, practice runs, and precise execution resulted in successful completion of the operation with less than permissible one-day exposures for all personnel.

5.2 X-ray Safety Program

Each of the 74 units presently registered were resurveyed during the year. Results of the survey indicate that most of the x-ray facilities were in compliance with ORNL and ANSI safety standards. Recommendations were made to improve beam barrier systems on four analytical x-ray machines.

An accidental x-ray exposure to the hand of an individual working at another site resulted in a Laboratory-wide search by Instrumentation and Control personnel to identify units which might have similar "accident prone" features. Although ORNL x-ray facilities do not utilize interlock configurations exactly like the one involved in the accidental exposure, it was found that a similar failure could occur, but with a much lower probability. As a result of this finding, and discussion with Office of Laboratory and Personnel Protection, Instrumentation and Control personnel were instructed to design and fabricate a device which employs a voltage sensor to energize a warning light each time high voltage is applied to the primary of the x-ray high voltage transformer. A device of this type is to be installed on all x-ray units requiring it.

5.2.1 Microwave Safety Program

The number of microwave ovens in use at the Laboratory increased from 21 to 30 during the year. Each of the ovens was surveyed quarterly for microwave leakage and interlock integrity. Leakage on all units was found to be within federal limits. One of the older units was found to have a slightly elevated leakage rate due to a dirty door seal; the condition was corrected by cleaning the seal. Another unit was found to give momentarily elevated leakage levels when an attempt was made to open the door with the unit energized. A fault in a portion of the interlock system was the cause of the latter problem.

5.3 Special Programs Assistance

Assistance in other programs included the following:

Neutron Surveys with Threshold Detector Units

Radiation and Safety Surveys personnel were assigned the responsibility for application of a threshold detector system previously used by the Radiation Dosimetry Section of the Health Physics Division. The threshold detector contains fissile material placed next to a thin polycarbonate film. The assembly is useful in neutron dosimetry measurements in environments not amenable to the use of rate meter devices. The system was used twice during 1977. One occasion was the measurement of neutron fluences inside the containment shell of an operating power reactor. The other was for the purpose of determining the source strength of a large Sb-Be neutron source.

Accelerator Produced Neutron Yield Measurements

Industrial Safety and Applied Health Physics survey personnel, in collaboration with Physics Division personnel, made a series of measurements to determine neutron yields from a variety of heavy ion beams on various targets. The ions accelerated ranged from carbon to neon (with energies ranging from 35 to 180 MeV), while the atomic number of the targets ranged from 6 to 73. The Isochronous Cyclotron at Building 6000 and the Tandem Van de Graaff at Building 5500 provided the ion beams. One possible application of the data will be the estimation of dose equivalent rates under a variety of beam and target combinations in areas at the new Heavy Ion Laboratory.

Off-Site Pollutants Measurements

Section personnel rendered 19 man-weeks of surveillance services to the Off-Site Pollutants Measurements Group of the Health and Safety Research Division in their efforts to evaluate the significance of residual contamination at a number of sites where radioactive materials had been used or processed in facilities under the jurisdiction of the Manhattan Engineering District or Atomic Energy Commission.

5.4 Laundry Monitoring

Approximately 483,000 articles of wearing apparel and 161,000 articles such as mops, laundry bags, towels, etc. were monitored at the Laundry during 1977. Approximately five percent were found contaminated. Of 339,855 khaki garments monitored during the year, only 38 were found contaminated.

A total of 4,008 full face respirators and 3,747 canisters were monitored during the year. Of this number 365 required further decontamination after the first cleaning cycle.

5.5 Radiation Incidents

The term "radiation incident" is applied to describe an undesirable operational occurrence involving radiation or radioactive materials and is further defined in Procedure 2.6 of the ORNL Health Physics Manual. There were 15 such occurrences in 1977 (may be compared to 17 which occurred in 1976). All were classified as being of minor significance.

6.0 INDUSTRIAL SAFETY AND SPECIAL PROJECTS

The excellent safety record established during 1977 included maintaining the lowest disabling injury frequency rate in the history of the Laboratory. Only one disabling injury occurred during the year, and ORNL employees worked a continuous period of 263 days without a disabling injury. For the third consecutive year the Laboratory earned the highest awards of both the Union Carbide Corporation and the National Safety Council: the Award of Distinguished Safety Performance and the Award of Honor.

6.1 Accident Analysis

The disabling injury frequency rate (DIFR)[1] for 1977 of 0.12 was the lowest since inception of the Laboratory. The recordable injuries and illnesses frequency rate (RIIFR)[2] of 1.60 was was the second best recorded within the Nuclear Division facilities. The injury statistics for ORNL for the period 1970-1977 are shown in Table 6.1.1, page 76. The disabling injury history of ORNL for the past five years is shown in Table 6.1.2, page 77; and the disabling injury frequency rate since inception of Carbide's contract as compared with NSC, DOE and UCC are shown in Table 6.1.3, page 78.

Seventeen ORNL divisions did not have a recordable injury or illness in 1977. Injury statistics by divisions are shown in Table 6.1.4, page 79.

Disabling injury accident-free periods for ORNL are shown in Table 6.1.5, page 80. From Septebmer 17, 1976, throught April 24, 1977, the Laboratory accumulated over 4.5 million manhours without a disabling injury.

Table 6.1.6, Figure 6.1.1, and Table 6.1.7, pages 81, 82, and 83, present ORNL injury data according to type, part of body injured, and nature of injury.

A tabulation of the injuries for the four UCC-ND facilities is shown in Table 6.1.8, page 84. ORNL frequency rate of 0.12 for disabling injuries was the lowest in the history of the Laboratory, and also established the best record within the Nuclear Division facilities.

Statistics on motor vehicle accidents, fires and off-the-job injuries are shown in Tables 6.1.9, 6.1.10 and 6.1.11, pages 85 and 86.

Off-the-job disabling injury frequency rate for ORNL employees was 1.98 compared with ORGDP's frequency rate of 4.37, Paducah's 3.70 and Y-12's rate of 5.16. There were no off-the-job fatalities occurring during 1977.

---

[1] $$\text{DIFR} = \frac{\text{Number of Disabling Injuries X 1,000,000}}{\text{Employee Hours of Exposure}}$$

[2] $$\text{RIIFR} = \frac{\text{Number of Recordable Injuries and Illness X 200,000}}{\text{Employee Hours of Exposure}}$$

6.2 Summary of Disabling Injury

The following is a summary of the disabling injury that occurred in 1977: Date of Injury - April 25, 1977.

A machinist sustained a traumatic bruise of the right hip and sciatica in a fall which resulted when he stepped on a piece of conduit. The accident occurred as the machinist was attempting to move a small cabinet in preparation to performing work on an Electron Beam Welder. As he started to move the cabinet only the top moved, and when he stepped back to get a hand hold on the lower part of the cabinet he stepped on the piece of conduit and fell to the floor. Time loss: 70 days.

6.3 Safety Awards

Each Laboratory employee at the X-10 site and on the payroll as of December 31, 1977, earned an $18.00 value safety award. The safety incentive plan is the same as that which was in effect during 1976. Each employee will have an opportunity to select from an award booklet containing over one hundred merchandise items. The items chosen will be mailed directly to the home of the employees.

Table 6.1.1 ORNL Injury Statistics (1960-1977)

Year	Disabling Injuries			Recordable Injuries and Illnesses	
	Number	Frequency	Severity	Number	Frequency
1960	6	0.94	77	99	15.5
1961	10	1.55	576	80	12.4
1962	10	1.45	377	70	10.2
1963	11	1.55	172	58	8.2
1964	8	1.07	148	83	11.1
1965	18	2.34	366	97	12.6
1966	5	0.64	155	93	11.9
1967	4	0.50	266	89	11.1
1968	1	0.13	8	73	9.4
1969	2	0.27	9	37	4.9
1970	5	0.76	88	49	7.5
1971	4	0.61	298	38	5.8
1972	7	1.08	52	49	7.6
1973	2	0.33	24	35	5.8
1974	5	0.81	51	30	4.9
1975	2	0.27	24	82	2.25*
1976	1	0.13	14	51	1.33
1977	1	0.12	9	64	1.60

* Since 1975, the serious injury frequency rate has been based on OSHA system for recording injuries and illnesses.

Table 6.1.2 Disabling injury History - ORNL (1973-1977)

	1973	1974	1975	1976	1977
Number of Injuries	2	5	2	1	1
Labor Hours (Millions)	6.0	6.2	7.3	7.6	8.0
Frequency Rate	0.33	0.81	0.27	0.13	0.12
Days Lost or Charged	692	315	173	106	70
Severity Rate	115	51	24	14	9

Table 6.1.3 ORNL Disabling Injury Frequency Rates Since Inception of Carbide Contract Compared with Frequency Rates for NSC, ERDA and UCC

Year	ORNL	NSC	ERDA*	UCC
1948	2.42	11.49	5.25	5.52
1949	1.54	10.14	5.35	4.91
1950	1.56	9.30	4.70	4.57
1951	2.09	9.06	3.75	4.61
1952	1.39	8.40	2.70	4.37
1953	1.43	7.44	3.20	3.61
1954	0.79	7.22	2.75	3.02
1955	0.59	6.96	2.10	2.60
1956	0.55	6.38	2.70	2.27
1957	1.05	6.27	1.95	2.41
1958	1.00	6.17	2.20	2.21
1959	1.44	6.47	2.15	2.16
1960	0.94	6.04	1.80	1.92
1961	1.55	5.99	2.05	2.03
1962	1.45	6.19	2.00	2.28
1963	1.55	6.12	1.60	2.10
1964	1.07	6.45	2.05	2.20
1965	2.34	6.53	1.80	2.40
1966	0.64	6.91	1.75	2.57
1967	0.50	7.22	1.55	2.06
1968	0.13	7.35	1.27	2.24
1969	0.27	8.08	1.52	2.49
1970	0.76	8.87	1.28	2.27
1971	0.61	9.37	1.44	2.05
1972	1.08	10.17	1.40	1.73
1973	0.33	10.55	1.45	1.50
1974	0.81	10.20	1.60	0.99
1975	0.27	13.10	2.50	0.61
1976	0.13	10.87	1.04	0.86
1977	0.12	-----	----	0.67

*ERDA replaced by Department of Energy (DOE) as of October 1977.

Table 6.1.4 Injury Statistics by Division--1977

Division	Medical Reports Received	Recordable Injuries and Illnesses		Disabling Injuries			Exposure Hours (In Millions)
		Number	Frequency	Number	Frequency	Severity	
Analytical Chemistry	6	0	0				.229
Chemical Technology	20	2	0.69				.576
Chemistry	14	0	0				.212
Central Management	2	0	0				.096
Physics	7	0	0				.201
Instr. and Controls	21	3	1.10				.545
Ind. Safety & AHP	4	0	0				.155
Metals and Ceramics	13	0	0				.546
Neutron Physics	4	0	0				.140
Computer Sciences	5	0	0				.394
H & S Research	3	0	0				.191
Solid State	3	0	0				.177
Engineering	4	0	0				.502
Health	2	0	0				.066
QA & Inspection	4	0	0				.073
Laboratory Protection	8	0	0				.213
Operations	26	3	1.07				.562
Employee Relations	7	0	0				.209
Plant and Equipment	239	49	5.93	1	0.60	42.	1.653
Information	12	3	1.23				.487
Environmental Sciences	15	1	0.71				.283
Rockville Laboratory	0	0	0				.015
Energy	5	0	0				.164
Finance and Materials	16	3	1.92				.312
PLANT TOTAL	440	64	1.60	1	0.12	9	8.017

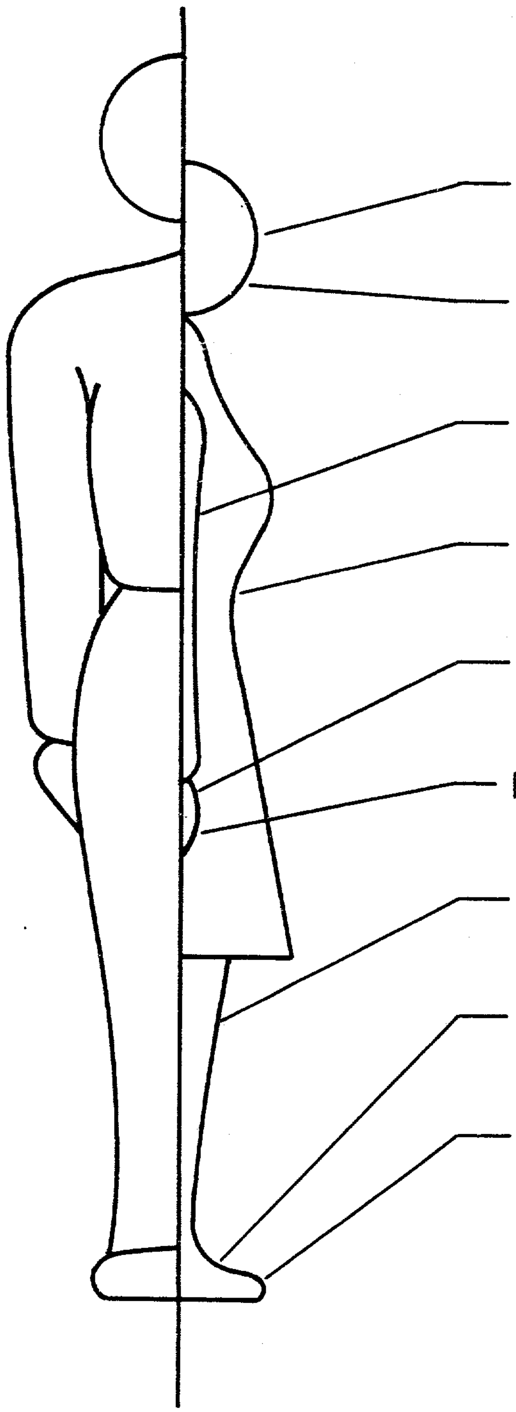
Table 6.1.5 Disabling Injury Accident - Free Periods--ORNL (1972-1977)

Accident-Free Period	Man-Hours Accumulated
December 12, 1972 - April 25, 1973	2,327,051
April 27, 1973 - July 29, 1973	1,428,975
July 31, 1973 - January 15, 1974	2,760,549
January 17, 1974 - May 6, 1974	1,869,338
May 8, 1974 - June 15, 1974	661,399
June 17, 1974 - August 11, 1974	926,437
August 13, 1974 - December 5, 1974	2,010,547
December 7, 1974 - April 6, 1975	2,570,944
April 8, 1975 - November 10, 1975	4,543,462
November 12, 1975 - September 15, 1976	6,375,994
September 17, 1976 - April 24, 1977	4,588,847
April 26, 1977 - January 14, 1978	5,830,521
Best Accident-Free-Period	
July 4, 1968 - August 20, 1969	8,529,750

Table 6.1.6 Number and Percent of Accidents by Type - 1977

Type of Accident	Number	Percent
Struck Against	176	40.0
Struck By	118	26.8
Slip, Twist	35	8.0
Caught In, On, Between	36	8.2
Contact with Temp. Extremes	17	3.9
Fall, Same Level	36	8.2
Inhalation, Absp., Ingestion	3	0.7
Fall, Different Level	4	0.8
Other	15	3.4
TOTAL	440	100.0

ORNL-DWG 77-5241



BODY AREA	%	TOTAL INJURIES
EYES	6.4	28
HEAD	8.6	38
ARMS	10.9	48
TRUNK	10.0	44
HANDS	9.5	42
FINGERS	33.6	148
LEGS	11.6	51
FEET	5.5	24
TOES	1.6	7
GENERAL	2.3	10

Fig. 6.1.1 Part of Body Injured

Table 6.1.7 Number and Percent of Accidents
by Nature of Injury - 1977

Nature of Injury	Number	Percent
Laceration, Puncture	188	42.7
Contusion, Abrasion	109	24.8
Strain	34	7.7
Burn, Temperature	31	7.0
Sprain	15	3.4
Conjunctivitis	20	4.5
Burn, Chemical	7	1.6
Other	36	8.3
TOTAL	440	100.0

Table 6.1.8 Tabulation of Injuries by UCC-ND Facility--1977

Plant	Labor Hours (Millions)	Disabling				Recordable Injuries and Illnesses	
		Number of Injuries	Frequency Rate	Days Lost or Charged	Severity Rate	Number of Injuries*	Frequency Rate
ORNL	8.0	1	0.12	70	9	64	1.60
ORGDP	11.8	4	0.34	238	20	134	2.26
Y-12	11.4	2	0.18	181	16	79	1.39
Paducah	4.6	3	0.65	6,184	1,341	60	2.60

*Includes the number of Disabling Injuries.

Table 6.1.9 Motor Vehicle Accidents (1973-1977)

Year	Number	Frequency	Damage
1973	10	5.22	$ 915
1974	15	8.14	$1,968
1975	7	3.33	$2,567
1976	14	6.42	$5,136
1977	12	5.05	$8,488

Table 6.1.10 Number of Fires (1973-1977)

Year	Number	Damage
1973	20	$ 300
1974	8	$ 0
1975	8	$16,493
1976	0	$ 0
1977	0	$ 0

Table 6.1.11 Number and Type of Off-The-Job Disabling Injuries (1973-1977)

	1973	1974	1975	1976	1977
Transportation	5	8	14	20	11
Home	3	17	16	17	11
Public	5	10	6	9	12
Total	13	35	36	46	34
Days Lost	612	1197	1724	1251	765
Frequency	1.01	2.54	2.33	2.91	1.98
Fatalities	1	2	1	5	0

7.0 PRESENTATIONS

J. A. Auxier, "Brief Synopsis of Symposium," IAEA International Symposium on National and International Standardization in Radiation Dosimetry, Atlanta, Georgia, December 9, 1977.

J. A. Auxier, "Radiation Safety," Twenty-Fourth National Conference on Campus Safety, University of Hawaii at Manoa, Honolulu, Hawaii, June 9-16, 1977.

J. A. Auxier, "Need for Improved Standards in Neutron Personnel Dosimetry," International Specialists Symposium on Neutron Standards and Applications, Gaithersburg, Maryland, March 29, 1977.

J. S. Eldridge and T. W. Oakes, "Environmental Surveillance for Radionuclide Contamination Utilizing High-Resolution Gamma-Ray Spectroscopy," presented at the Eleventh Annual Conference on Trace Substances in Environmental Health, Columbia, Missouri, June 7-9, 1977.

J. S. Eldridge, W. S. Lyon, and T. W. Oakes, "Planning for Unplanned Releases," presented at the Symposium on the Monitoring Radioactive Airborne and Liquid Releases from Nuclear Facilities, pp. 89-97, Portoroz, Yugoslavia, September 7-9, 1977.

J. S. Eldridge, T. W. Oakes, and M. E. Pruitt, "Radioactive Pollutant Determination Using Gamma-Ray Spectroscopy," presented at the American Industrial Hygiene Conference, New Orleans, Louisiana, May 22-27, 1977.

J. S. Eldridge, T. W. Oakes, and J. E. Turner, "A Rapid Method for the Determination of Iodine-131 Concentration of Milk Due to Fallout," presented at the 22nd Annual Meeting of the Health Physics Society, Atlanta, Georgia, July 3-8, 1977.

W. M. Good and R. E. Goans, "In Vivo Detection of the Actinides, Part I: Continued Study of the Phoswich Detector," presented at the Health Physics Annual Meeting, Atlanta, Georgia, July 3-8, 1977.

R. E. Goans and W. M. Good, "In Vivo Detection of the Actinides, Part II: Analytical Techniques for Spectral Analysis," presented at the Health Physics Annual Meeting, Atlanta, Georgia, July 3-8, 1977.

T. W. Oakes and A. K. Furr, "The Distribution and Accumulation of Traceable Elements in Roadside Plants and Soils," presented at the 1977 American Association for the Advancement of Science Meeting, Denver, Colorado, February 20-25, 1977.

T. W. Oakes, E. D. Gupton, and K. E. Shank, "A Stream Monitor Control System for Widely Varying Flows," presented at the American Industrial Hygiene Conference, New Orleans, Louisiana, May 22-27, 1977.

T. W. Oakes, K. E. Shank, C. E. Easterly, and L. R. Quintana, "Concentrations of Radionuclides and Selected Trace Metals in Fruits and Vegetables," presented at the 11th Annual Conference on Trace Substances in Environmental Health, Columbia, Missouri, June 7-9, 1977.

T. W. Oakes, K. E. Shank, and C. E. Easterly, "Verification of an Air-Transport Code Using Idoine-131 as a Tracer," presented at the Twenty-Second Annual Meeting of the Health Physics Society, Atlanta, Georgia, July 3-8, 1977.

T. W. Oakes, K. E. Shank, and J. C. Danek, "Quality Assurance Applied to an Environmental Radiological Surveillance Program," presented at the 105th APHA Annual Meeting, Washington, D. C., October 30-November 3, 1977.

T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Quality Assurance Applied to an Environmental Surveillance Program," presented at the Fourth Joint Conference on Sensing of Environmental Pollutants, New Orleans, Louisiana, November 6-11, 1977.

W. W. Parkinson, Jr., R. E. Goans, and W. M. Good, "Realistic Calibration of Whole Body Counters for Measuring Plutonium," presented at the IAEA International Symposium on National and International Standardization in Radiation Dosimetry, December 5-9, 1977, Atlanta, Georgia.

W. W. Parkinson, Jr., T. W. Oakes, R. E. Goans, W. M. Good, and K. E. Shank, "Biological Monitoring Using a Whole Body Counter," presented at the Health Physics Annual Meeting, Atlanta, Georgia, July 3-8, 1977.

K. E. Shank, C. E. Easterly, and T. W. Oakes, "Assessment of Radiological Releases from a Fusion Reactor Power Plant", presented at the 22nd Annual Meeting of the Health Physics Society, Atlanta, Georgia, July 3-8, 1977.

K. E. Shank, C. E. Easterly, and T. W. Oakes, "Radiological Health Implications in Developing Fusion Power", presented at the 105th Annual Meeting of the Health Physics Society, Atlanta, Georgia, July 3-8, 1977.

J. E. Turner, K. E. Shank, A. S. Loebl, and C. E. Easterly, "The Role of the Health Physicist in the Development of Safe Energy Sources," presented at the 22nd Annual Meeting of the Health Physics Society, Atlanta, Georgia, July 3-8, 1977.

PUBLICATIONS

J. A. Auxier, "The Regulatory Pendulum, or, A Matter of Common Sense," American Industrial Hygiene Association Journal, December 1977.

J. A. Auxier, Ichiban: Radiation Dosimetry for the Survivors of the Bombings of Hiroshima and Nagasaki, ERDA Critical Review Series, TID-27080, (1977).

D. M. Davis, Industrial Safety and Applied Health Physics Annual Report for 1976, ORNL-5310, August 1977.

H. W. Dickson, T. W. Oakes, and K. E. Shank, "Occupational Radiation Exposure Control at Operating Nuclear Power Stations", Nucl. Safety, 18(4), pp. 492-501 (1977).

C. E. Easterly and K. E. Shank, Metabolic and Environmental Aspects of Fusion Reactor Activation Products: Niobium, ORNL/TM-5496, 1977.

C. E. Easterly, K. E. Shank, and R. L. Shoup, "Radiological and Environmental Aspects of Fusion Power", Nucl. Safety, 18(2), pp. 203-215 (1977).

J. S. Eldridge and T. W. Oakes, "Environmental Surveillance for Radionuclide Contamination Utilizing High-Resolution Gamma-Ray Spectroscopy," in Proceedings of the Eleventh Annual Conference on Trace Substances in Environmental Health, Columbia, Missouri, June 7-9, 1977

J. S. Eldridge, W. S. Lyon, and T. W. Oakes, "Planning for Unplanned Releases," in Proceedings of the Symposium on the Monitoring of Radioactive Airborne and Liquid Releases from Nuclear Facilities, pp. 89-97, Portoroz, Yugoslavia, September 5-9, 1977.

R. E. Goans, John H. Cantrell, Jr. and F. Bradford Meyers, "Ultrasonic Pulse-Echo Determination of Thermal Injury in Deep Dermal Burns," Med. Physics, Vol. 4, No. 4, pp. 254-263, July/ August 1977.

T. W. Oakes and K. E. Shank, Subsurface Investigation of the Energy Systems Research Laboratory Site at Oak Ridge National Laboratory, ORNL/TM-5695, July, 1977.

T. W. Oakes, A. K. Furr, D. J. Adair, and T. F. Parkinson, "Neutron Activation Analysis of Automobile Exhaust Pollutants," J. Radioanal. Chem. 37, No. 2, pp. 881-888 (1977).

T. W. Oakes, K. E. Shank, C. E. Easterly, and L. R. Quintana, "Concentrations of Radionuclides and Selected Stable Elements in Fruits and Vegetables," in Proceedings of the 11th Annual Conference on Trace Substances in Environmental Health Columbia, Missouri, June 7-9 1977.

T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Quality Assurance Applied to an Environmental Surveillance Program," in Proceedings of the Fourth Joint Conference on Sensing of Environmental Pollutants, pp. 226-231, New Orleans, Louisiana, November 6-11, 1977.

R. L. Roswell, R. E. Goans, J. H. Cantrell, Jr., High Resolution Ultrasonic Scanning of Animal and Human Tissue In Vivo, ORNL/TM-5934, August 1977.

K. E. Shank, R. J. Vetter, and P. L. Ziemer, "A Mathematical Model of Cadmium Transport in a Biological System," J. Env. Res., 13, pp. 209-214 (1977).

K. E. Shank, R. J. Vetter, and P. L. Ziemer, "Uptake and Distribution of Cadmium in Mice Following Repeated Administrations", Arch. Environ. Contam. & Toxicol., 6, pp. 63-68 (1977).

LECTURES

J. F. Alexander

"Microwave Hazards and Microwave Safety," 1977 Summer Facility Institute ORNL.

J. A. Auxier

"Dosimetry for Coexistent Neutron Gamma Ray Fields," presented at San Diego State University, San Diego, California, November 29, 1977.

"Radiation Measurement Technology," presented to Atlanta Chapter, Health Physics Society, Atlanta, Georgia, November 17, 1977.

"Radiation Measurement Technology," presented to Alabama Chapter, Health Physics Society, Huntsville, Alabama, October 28, 1977.

"The Effects of Radiation on Humans," presented at the Hawaii Health Physics Society and Nuclear Medicine Society Meeting, Honolulu, Hawaii, June 13, 1977.

"Cleaning Up Old Sites Associated With the Uranium Fuel Cycle," presented to the Southern California Chapter, Health Physics Society, Los Angeles, California, June 9, 1977.

W. D. Carden

"Principles of Radiation Protection," Dillis Elementary School, Dillis Community, Harriman Area, Tennessee, May 1977.

"Generation and Use of Electricity in Tennessee: Environmental Problems and Methods for the Safe Use of Nuclear Power," Doyle Middle School, Knoxville, Tennesse, October 13, 1977.

T. G. Clark

"Beta-Gamma Monitoring," given to Fuel Cycle Development Group in Chemical Technology Division at ORNL, September 6, 1977.

R. E. Goans

"Ultrasonic Analysis of Burn Necrosis," National Institutes of Health, Washington, D. C., February 1977.

"In Vivo Counting," Health Physics Technician Program, ORNL, March 7-9, 1977.

"Laboratory Assessment of Body Burdens," Medical Planning and Care in Radiation Accidents Course, ORAU, March 1977.

"Whole Body Counting of Actinides," NRC Course on Health Physics and Radiation Protection, ORAU, April 1977.

"Whole Body and Lung Counting," Radiation Protection Engineering Course, ORAU, June 1977.

C. E. Haynes

"Practical Problems With Health Physics Survey Instruments," Ten-Week Health Physics and Radiation Protection Course, sponsored by USNRC, ORAU, Feb.-May 1977.

"Transuranium Element Health Physics," Ten-Week Health Physics and Radiation Protection Course, sponsored by USNRC, ORAU, Feb.-May 1977.

"Principles of Radiation Protection," Dillis Elementary School, Dillis Community, Harriman Area, Tennessee, May (1977).

"Generation and Use of Electricity in Tennessee: Environmental Problems and Methods for the Safe Use of Nuclear Power," Doyle Middle School, Knoxville, Tennessee, October 13, 1977.

R. B. Malcolm

"Safety Orientation Meeting for New Employees and Summer Personnel," held in the Experimental Sections, Chemical Technology Division, ORNL, July 20, 1977.

R. E. Millspaugh

"Applied Radiation Protection," presented at the Symposium On Uses of Radiation, sponsored by Occupational Health Nurses, Chattanooga, Tennessee, October, 1977.

"Applied Radiation Protection," presented at the Kentucky Public Health Association Annual Meeting, Louisville, Kentucky, April, 1977.

T. W Oakes

"Environmental Monitoring at ORNL," visiting group from West Virginia Wesleyan College, Oak Ridge National Laboratory, January 6, 1977.

"Energy and the Environment," Science Classes, Knox Doss Junior High School, Hendersonville, Tennessee, February 14, 1977.

"Nuclear Power and the Environment," Science Classes, Knox Doss Junior High School, Hendersonville, Tennessee, February 15, 1977.

"Environmental Monitoring During Normal Operations," Health Physics Technicians Program, ORNL, March 14, 1977.

"Environmental Monitoring Emergency Situations," Health Physics Technicians Program, ORNL, March 16, 1977.

"Upgrading Liquid and Gaseous Monitoring Systems," Environmental Sciences Division Staff Seminar, ORNL, April 15, 1977.

"Environmental Surveillance and Evaluation Programs Around Nuclear Facilities," Ten-Week Physics and Radiation Protection Course, ORAU, April 18, 1977.

"Environmental Monitoring Under Emergency Conditions," Ten-Week Physics and Radiation Protection Course, ORAU, April 20, 1977.

"Environmental Surveillance at the Oak Ridge National Laboratory," Ten-Week Physics and Radiation Protection Course, ORAU, April 20, 1977.

"Environmental Surveillance Around Energy Installations," Seminar at the School of Nuclear Engineering, Georgia Institute of Technology, Atlanta, Georgia, July 7, 1977.

"Environmental Analysis," presented to the members of the East Tennessee Chapter of the Health Physics Society, September 29, 1977.

K. E. Shank

"Health Physics Aspects of Fusion Power Development," ORNL Health Physics Faculty Institute, Oak Ridge, Tennessee, June 1977.

"Environmental Monitoring at Oak Ridge National Laboratory," ORNL Health Physics Faculity Institute, Oak Ridge, Tennessee, June 1977.

"Fundamentals of Environmental Surveillance," National Registry of Radiation Protection Technologists Examination Review, East Tennessee Chapter of the Health Physics Society, Oak Ridge, Tennessee, October 1977.

TRAINING COURSES

Presented

"Laboratory Assessment of Body Burdens," Medical Planning and Care in Radiation Accidents Course, Oak Ridge Associated Universities, November 9, 1977 J. A. Auxier

Defensive Driving Course - Formal training courses started during 1977 and continuing. Over eight hundred employees have completed the course and two Laboratory divisions with 100% employee participation - Instructor, E. M. Robinson

Attended

Management Oversight Risk tree (MORT)
Chicago Illinois, March 1977, A. D. Warden
Oakland, California, June 1977, T. J. Burnett
Augusta, Georgia, October 1977, R. E. Millspaugh

Management Oversight Risk Tree (Accident Investigators Course)
Sun Valley, Idaho, May 1977, D. C. Gary
Lake Buena Vista, Florida, November 1977, T. J. Burnett

Safety Management Techniques (National Safety Council Course)
Chicago Illinois, November 1977, R. E. Millspaugh

The Design Structure of Technical Writing
ORNL, January 1977, T. J. Burnett

ORNL Technical Presentation Course, February - March 1977, K. E. Shank

Laboratory Safety: Recognition and Management of Hazards, "American Chemcial Society, New Orleans, Louisiana, March 18-20, 1977, C. E. Haynes

Hazardous Chemical Safety School and Workshop," J. T. Baker Chemical Co., Davidson Conference Center, University of Southern California, Los Angeles, California, October 17-18, 1977, C. E. Haynes

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

J. A. Auxier

President of Health Physics Society, 1977-78; National Council on Radiation Protection and Measurements; National Academy of Sciences Advisory Committee on Civil Defense; National Academy of Sciences Subcommittee on Radiation Shielding; ICRU Task Group on Neutron Instrumentation; U.S. American National Standards Institute Subcommittee N13.8; NCRP Scientific Committee 34; NCRP Scientific Committee 28; NCRP Scientific Committee 57; IAEA Panel on Nuclear Accident Dosimetry Systems; ICRP Task Group on Emergency and Accidental Exposures; Joint SNS/BER Biomedical Working Group; American Industrial Hygiene Association: Special Consultant to the Radiation Effects Research Foundation, Hiroshima, Japan; Enewetak Advisory Group.

T. J. Burnett

American National Standards Institute (ANSI), N45 -Reactor Plants and Their Maintenance Committee; N46 -Nuclear Reactor Fuel Cycle Committee; Health Physics Society History Committee.

A. C. Butler

Member Board of Directors of National Registry of Radiation Protection Technologists (NRRPT).

R. E. Goans

Enewetak Radiation Safety Audit and Inspection Team.

W. S. Nichols

News Editor, Health Physics Journal.

T. W. Oakes

American Nuclear Society, Chairman, Public Relations Committee, Oak Ridge, Tennessee Chapter (1976-1978); Health Physics Society, Councilman, East Tennessee Chapter (1977-79); Chairman, Subcommittee No. 9 of the project on "Upgrading of the Quality of Environmental Radiation Data" - National (1977-79); Member, National Program Committee (1976-78).

K. E. Shank

Health Physics Society, Chairman, Education and Certification Committee, East Tennessee Chapter (1977); Member, Audio-Visual Committee, East Tennessee Chapter (1977); Secretary, Subcommittee No. 9 of the project on "Upgrading of the Quality of Environmental Radiation Data", National Health Physics Society (1977-79).

A. D. Warden

American National Standards Institute (ANSI), N16-Transportation of Fissile and Radioactive Materials Committee.

ORNL-5420
Dist. Category UC-41

Internal Distribution

1. Biology Library
2-4. Central Research Library
5. Laboratory Shift Supervisor
6. ORNL -- Y-12 Technical Library
Document Reference Section
7-43. Laboratory Records Department
44. Laboratory Records, ORNL R. C.
45. R. L. Atchley
46. R. L. Auble
47-49. J. A. Auxier
50. W. M. Ayers
51. B. M. Beeler
52. N. A. Betz
53. R. D. Birkhoff
54. F. R. Bruce
55-57. G. H. Burger
58. T. J. Burnett
59. G. C. Cain
60. G. T. Chapman
61. M. M. Chiles
62-73. R. L. Clark
74. B. L. Corbett
75. R. A. Crowell
76-89. D. M. Davis
90. D. G. Doherty
91. R. S. Edwards
92. C. B. Fulmer
93. D. C. Gary
94. R. E. Greene
95-100. E. D. Gupton
101. H. F. Hartman
102. C. C. Hopkins
103. C. E. Haynes
104. R. F. Hibbs
105. J. A. Holloway, Jr.
106. E. J. Howard, Sr.
107. J. T. Howe
108. J. R. Jones
109. R. W. Knight
110. John M. Miller
111. W. H. Miller, Jr.
112. C. A. Mills
113. T. W. Oakes
114. L. F. Parsly
115. J. E. Parham
116. R. G. Pope
117. H. Postma
118. W. E. Porter
119. J. L. Rich
120. O. A. Rogers
121. J. B. Ruch
122. R. L. Senn
123. M. H. Shanks
124. J. J. Smith
125. D. R. Stallions
126. B. L. Tidwell
127. A. A. Walls
128. A. D. Warden
129. G. R. Wilson
130. R. H. Winget

External Distribution

131. Director, Reseach and Technical Support Division, DOE-ORO.
132-382. Given distribution as shown in TID-4500 under Health and Safety category (25 copies - NTIS).